

**INTERACTIVE HOMEWORK: A TOOL FOR PARENT MATHEMATICS  
ENGAGEMENT**

by  
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## **Abstract**

Families have largely been excluded from the implementation of the Common Core State Standards (CCSSM), reducing their ability to extend their child's mathematics learning. CCSSM emphasizes different instructional elements (e.g., pictorial representations, problem solving, multiple strategies for solving) that differ greatly from how parents learned mathematics. In addition, many school officials have ineffectively engaged parents, further diminishing their capacity to participate in their child's learning. This study examined parent mathematics self-efficacy and parent mathematics knowledge for teaching, factors that influence the effectiveness of parent mathematics engagement. A case study was conducted to determine if interactive homework improved parent mathematics self-efficacy and parent mathematics knowledge for teaching. This study was also implemented to identify elements that the parent participant found helpful for their child's mathematics learning. The data sources, the interactive homework assignments, a survey, observations, a researcher's journal, and an interview were triangulated to conclude that the interactive homework assignments improved parent mathematics self-efficacy and parent mathematics knowledge for teaching. The parent participant also identified the assignments' side-by-side examples, additional practice, and the easy access of the assignments as features of the intervention that enhanced her ability to support her child. Another outcome research emerged after the intervention ended in which the researcher found that the child participant's initiative and abilities also improved.

*Keywords:* interactive homework assignments, mathematics knowledge for teaching, mathematics self-efficacy, parents

Dissertation Advisor: Robert N. Ronau

## **Dedication**

This dissertation is dedicated to my grandmother, Laura Jean Smith.

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## **Executive Summary**

Conceptual approaches to teaching, emphasized by the Common Core State Standards for Mathematics (CCSSM), support a deep student understanding of mathematics through pictorial representations and problem solving (CCSSO & NGA, 2019). Parents in the United States have struggled to embrace these strategies, negatively affecting their reinforcement of their children's mathematics learning (Green, 2014). Interactive homework assignments were designed to improve parents' mathematics engagement through activities that emphasize collaborative learning, mathematics tasks for problem solving, direct guidance on knowledge of content and teaching (KCT), emotional support, and self-guiding tools. A case study was implemented to examine the effectiveness of interactive homework on parent mathematics self-efficacy and parent mathematics knowledge for teaching.

## **Historical Background**

In the 1980s, the Reagan Administration's Education Secretary, Terrel Bell, released *A Nation at Risk*, which characterized schools in the United States as failing due to decreasing SAT scores and student inability to compete with other developed nations on international tests (Mehta, 2013). Policymakers projected that the nation's economic prosperity depended on instruction and promoted greater national and state government involvement in school systems (Mehta, 2013). The Board of Directors of the National Council of Teachers of Mathematics (NCTM), who advocated for American educational reforms through the Priorities in School Mathematics (PRISM) project in the 1970s (NCTM, 1981), also continued to recommend reforms in their *Agenda for Action* in the 1980s (NCTM, 1980). NCTM opposed the *Back to Basics* mathematics movement, which focused on rote learning and one way for problem solving (Schoenfeld, 2004). NCTM promoted mathematics instruction that developed a deep understanding of mathematics through hands-on learning, group work, math games, and problem

solving connected to real-world application (NCTM, 1980). *A Nation at Risk* provided additional support for NCTM's reform ideas, and NCTM created the *Curriculum and Evaluation Standards for School Mathematics*, guidelines intended for policymakers to use for improving mathematics instruction (NCTM, 1980).

Although NCTM promoted their guidelines for decades (NCTM, 1980), international assessments, such as Trends in International Mathematics and Science Study (TIMSS), the National Assessment of Education Program (NAEP), the Program for International Assessment of Adult Competencies (PIAAC), and Program for International Student Assessment (PISA), continued to indicate that citizens lacked basic mathematics skills (Boser, Baffour, & Vela, 2016; Serino, 2017). In 2009, in response to poor performances on international tests and the fact that the highest achieving countries had similar academic standards, the Council of Chief State School Officers (CCSSO) and the National Governors Association Center for the Best Practices (NGA) developed and implemented the Common Core State Standards (CCSS) (CCSSO & NGA, 2019). CCSS incorporates NCTM guidelines and represents a reform movement that addresses both content and practice for the U.S. school system (CCSSO & NGA, 2019). CCSSO and NGA spent multiple years collaborating with additional stakeholders (e.g., teachers, administrators, mathematicians) to develop and evaluate sets of standards for language arts and mathematics. Forty-one states adopted the CCSS (CCSSO & NGA, 2019).

### **Problem of Practice**

The definition of *parent* for this study is the primary caregiver (Williams & Williams, 2019), or adult who is principally responsible for extending the child's learning and reinforcement of school instruction (Mangram & Metz, 2018). Parents from the United States encounter many obstacles in finding ways to effectively participate in the development of their children's mathematical abilities (Green, 2014). Although policymakers and researchers regularly discuss

the importance of parental involvement (Mattingly, Prislin, McKenzie, Rodriques, & Kayzar, 2002), today's parents are confronted with a form of learning that they have never experienced and find difficult to understand (Jackson & Remillard, 2005; Jay, Rose, & Simmons, 2018; Marshall & Swan, 2010; Remillard & Jackson, 2006). Many adults learned mathematics that emphasized rote learning and one way of solving a problem (Goldman & Booker, 2009; Jackson & Remillard, 2005; Remillard & Jackson, 2006); however, the Common Core State Standards for Mathematics (CCSSM) emphasize a conceptual understanding of mathematics, procedural fluency, and multiple strategies for problem solving (CCSSO & NGA, 2019). Unfamiliarity with mathematics instruction has been associated with negative mathematics beliefs (Drešar & Lipovec, 2017; Jay, Rose, & Simmons, 2017), a resistance to learning mathematics (Bartlo & Sitomer, 2008; Thomas & Cooper, 2016), and an inability to connect school mathematics to everyday problem-solving activities with their children (Goldman & Booker, 2009; Remillard & Jackson, 2006). Furthermore, few schools have found meaningful ways to educate parents of varied racial, ethnic, and socioeconomic backgrounds (Turney & Kao, 2009; Yoder & Lopez, 2013), contributing to persistent learning disparities among students (Voight, Hanson, O'Malley, & Adekanye, 2015) when mathematics understanding is critical for social mobility and career opportunities (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017). The purpose of this study is to determine the personal and school-based barriers parents would encounter when they engage their children in mathematics learning at home and then to discover strategies for how the school can address these barriers to promote student and parent success in mathematics.

### **Parent Involvement**

Parent involvement has many definitions (Jackson & Remillard, 2005). Fan (2001) identified seven parts of parental involvement: (a) rules for television use, (b) communication,

(c) school contact, (d) parent-teacher relationship, (e) volunteering, (f) supervision, and (g) aspirations and expectations for children. Epstein (1992) identified six types of parent involvement that involve school and home communication: (a) parenting (such as parent education workshops and other courses for parents), (b) communicating, (c) volunteering, (d) learning at home, (e) decision making, and (f) collaborating with the community. However, Bower and Griffin (2011) questioned if Epstein's (1992) model sufficiently addressed the different ways minority and low-income parents participated in their children's learning. For example, Bower and Griffin (2011) reported that Epstein's (1992) model did not include participating in church activities, which is a common form of involvement for African American families. Hoover-Dempsey et al. (2005) discussed three forms of parent involvement, which are home-based (homework assistance), school-based (school events), and communication. Researchers classified parent involvement by school and home involvement (Deslandes & Bertrand, 2005; Green, Walker, Hoover-Dempsey, & Sandler, 2007; Moroni, Dumont, Trautwein, Niggli, & Baeriswyl, 2015). In addition, Silinskas, Niemi, Lerkkanen, and Nurmi (2013) further deconstructed parent homework participation by examining the effects of two types of homework assistance, monitoring (checking) and helping (guiding the child during homework). Additionally, Moroni et al. (2015) classified homework assistance by the quantity and quality of parental homework help because many studies had inconclusive findings that focused on the quantity of homework sessions instead of the quality of homework sessions. Quantity of homework help is how frequently parents help with homework (Moroni et al. 2015), and quality of homework help includes opportunities for independent problem solving with "a clear structure to learning that develops a student's emotional wellbeing" (Knollmann & Wild, 2007, p.64). Knollmann and Wild (2007) also discussed how the quality of parental help is

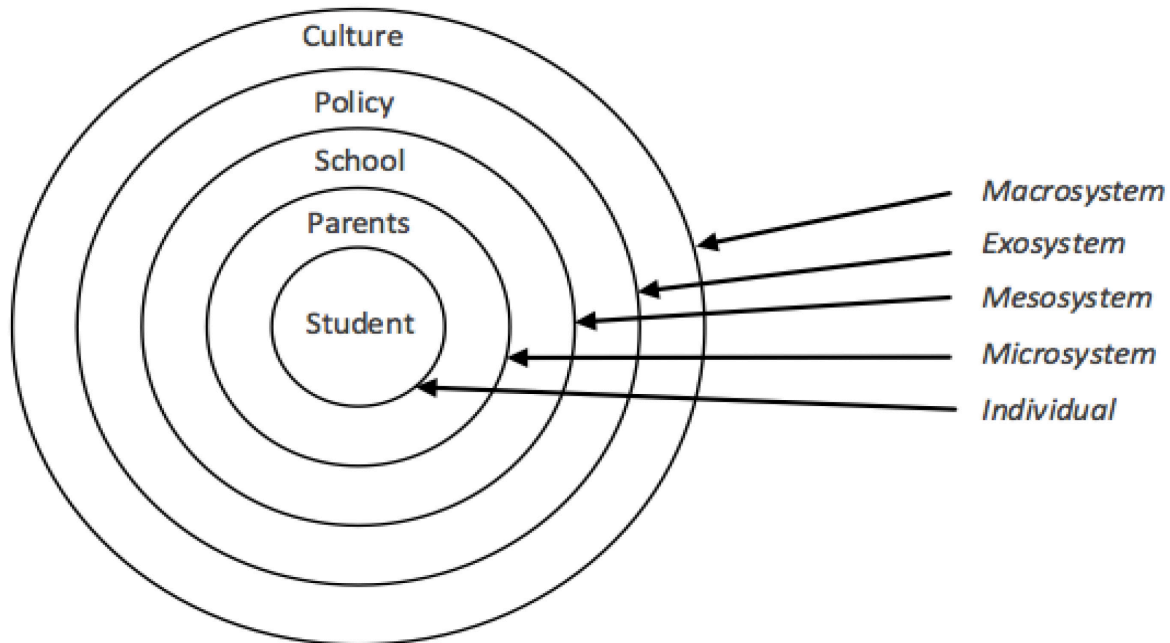
further complicated because extrinsically-motivated students favor directive parental support and intrinsically-motivated students favor learning conditions that allow for opportunities to learn independently. Moroni et al. (2015) reported that the quality of parental help increased student achievement, particularly if the child perceived their parents to be supportive during homework sessions, and according to Mistretta (2017) schools that support parents can create opportunities for them to provide quality mathematics homework sessions.

### **Theoretical Framework**

The theoretical framework for examining existing literature about obstacles parents encounter is Bronfenbrenner's (1994) ecological systems theory (EST). Each system is embedded within the other, demonstrating how the systems' influences are intertwined. As Figure 1.1 demonstrates, the microsystem includes close persons that directly affect the child's development, such as parents and guardians. The microsystem, specifically in regards to parent characteristics and behaviors, will be further explored in chapter two to identify actionable factors that can aid parent mathematics engagement. Obstacles will be examined through an expanded lens of the mesosystem, consisting of interconnected microsystems that influence the child's development, such as parent-teacher communications. The exosystem contains components that indirectly impact the child's development, like educational standards and policies that influence teacher preparation. The macrosystem will be examined, and this system contains parents' cultural and social beliefs. Five systems of EST have been described as they

will serve as the structures that house the conceptual framework, which is introduced in the next section.

*Figure 1.1. EST model. Adapted from Ecology models of human development by Urie*



Bronfenbrenner, 1994, Oxford, England: Elsevier

### **Conceptual Framework**

The conceptual framework (Figure 1.2) consists of interrelated constructs that influence how parents participate in their child's learning, and this framework resides in the EST. Ball, Thames, and Phelps' (2008) mathematics knowledge for teaching (MKT) theory describes the mathematics understanding that educators need for school instruction. They created the MKT to describe what teachers, those with a formalized education in instruction, must know to succeed in the classroom. Thus, a modified conception of this theory will guide the analysis of what parents need to know for reinforcing school instruction. Mathematics knowledge for teaching is the first microsystemic construct introduced.

Mathematics knowledge for teaching is a microsystemic construct because parents can directly influence their child's mathematics learning through their knowledge of content and knowledge of teaching. Mathematics orientation is the second microsystemic construct, and it includes mathematics instructional experiences, beliefs about mathematics learning, and mathematics self-efficacy. Mathematics orientation, located in the microsystem, contains the beliefs and attitudes that influence parent mathematics participation. Teacher-parent communication is a mesosystemic construct involving the interactions between teachers and parents, and this construct is influenced by the availability of resources and role construction. Teacher professional development and educational policies are located in the exosystem, due to their indirect impact on student mathematics learning. Culture is located in the macrosystem, influencing constructs located in all embedded ecological levels. Culture addresses how race, gender, socioeconomic status (SES), and national origin influence parental ability to extend mathematics learning outside of school. The constructs in the conceptual framework and their relationships are discussed in the literature review.



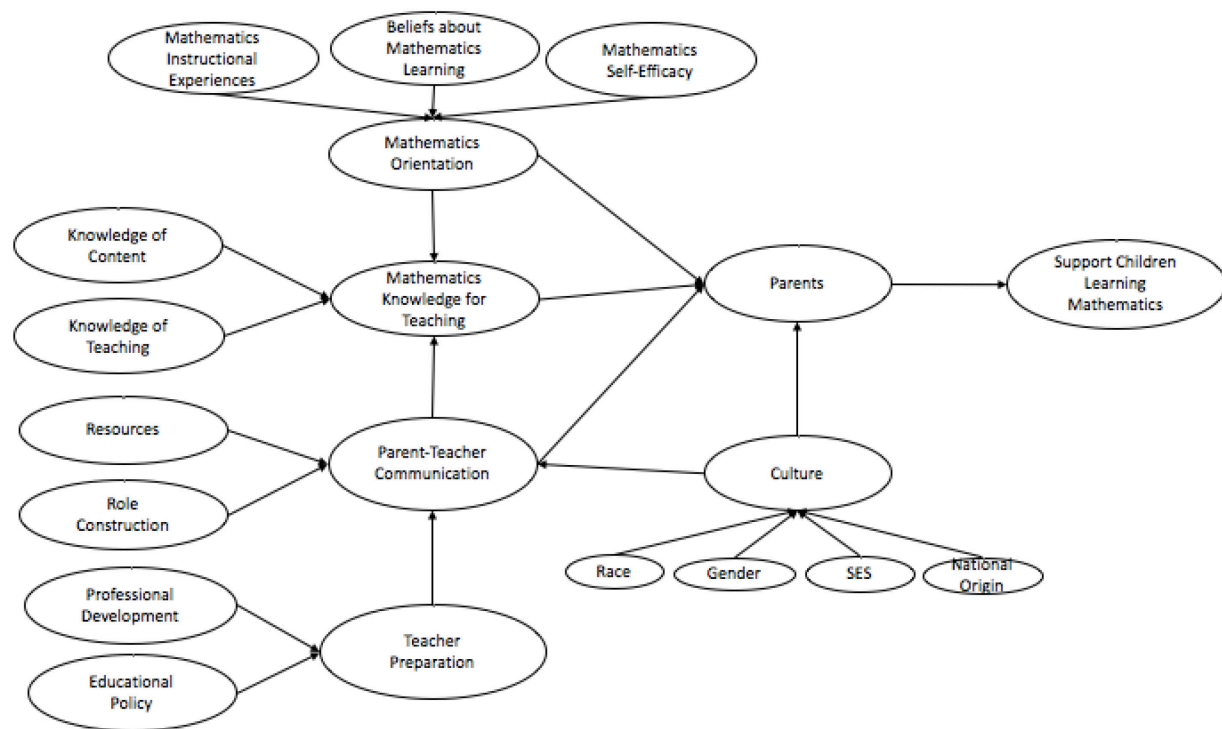


Figure 1.2. Conceptual Framework

## Literature Review

This dissertation explored how parent characteristics (i.e., mathematics orientation, mathematical knowledge) influence their roles in their child’s mathematics development. Factors regarding teacher-parent relationships (e.g., instructional roles, resources) and their impact on student learning were also addressed. Teacher professional development and educational policies were examined because they influence teacher preparation, and thus, parent involvement. Lastly, an overview of cultural components (e.g., race, SES, gender, national origin) and their role in parent involvement were explored.

## Microsystem: Parents

The microsystem encompasses the direct interactions between the child and the parent, as parents are important stakeholders due to their close proximity to their children (Bronfenbrenner,

1994). Duncan et al.'s (2007) analysis of the Early Childhood Longitudinal Study-Kindergarten Cohort found that learning gaps develop about five to six years before students receive a formal education, and mathematics scores at the start of kindergarten are significant predictors of success in high school. Overall, learning out of school plays a significant role in the academic achievement of U.S. students (Altonji & Mansfield, 2010; Coleman et al., 1996), suggesting that parents may be an untapped resource for helping students achieve the goals established by CCSSM before they participate in formal instruction. Kraft and Rogers' (2015) study of high school students in a summer credit recovery program required for high school graduation found that teachers communicating consistently with parents yielded a 41% reduction in the number of students who did not earn course credit. This finding suggests that parents can still impact their children's academic trajectories even when they are at the end of compulsory education. Thus, parents may have the ability to play an important role in their children's academic development (Kraft & Rogers, 2015) to reverse the trend of mathematics incompetency in the United States. The next sections focused on parents' mathematics orientations as a result of their instructional experiences, mathematics beliefs, and mathematics self-efficacy. The next sections also examined parent mathematics knowledge, which consists of knowledge of content and knowledge of teaching.

### **Mathematics Orientation**

Schoenfeld's (2013) definition of orientation will be adapted to establish the term *mathematics orientation*, and orientation is a category of an individual's knowledge and activities that include beliefs and values. Mathematics orientation will serve as an umbrella term for interrelated affective factors (e.g., instructional mathematics experiences, beliefs about mathematic learning, mathematics self-efficacy) to examine their effects on parents and their

ability to extend their child's mathematics learning. The next sections described the relationship between negative instructional mathematics experiences, negative mathematics beliefs, mathematics anxiety, and mathematics self-efficacy. Mathematics self-efficacy is described in greater detail due to its studied role in increasing mathematics engagement.

**Mathematics instructional experiences.** Many adults have developed a dislike and fear of mathematics in elementary school due to repeated poor mathematics performances, and these negative feelings often continue into adulthood (Sloan, 2010; Uusimaki & Nason, 2004). Parents' negative mathematics experiences and performances are factors that lead to mathematics anxiety and a lack of confidence in their mathematical skills and abilities to assist their children's mathematics learning (Carey, Hill, Devine, & Szücs, 2016; Ma & Xu, 2004). For some parents, helping their children with homework forces them to relive painful experiences and feelings of inadequacy from their childhoods (Jackson & Ginsburg, 2008; McMullen & de Abreu, 2011), creating additional negative instructional experiences for the parents.

**Beliefs about mathematics learning.** Self-beliefs, such as self-concept and self-efficacy, have a great impact on life outcomes (Bandura, 1986), and the triadic reciprocal determinism model demonstrates how cognitive abilities, actions, and environments affect each other (Bandura, 1986; Parker, March, Ciarrochi, Marshall, & Abduljabbar, 2014). Just as the triadic reciprocal determinism model demonstrates the relationship between cognitive abilities, actions, and environments, mathematics beliefs and mathematics attitudes also mutually influence each other. For example, low mathematics self-concept is one's perception that one is mathematically incompetent, and low mathematics self-concept predicts higher levels of mathematics anxiety, defined as one's fear of mathematics (Ahmed et al., 2012; Jameson & Fusco, 2014). Mathematics self-efficacy is the belief that one will be successful doing mathematics and

performing mathematics tasks in general (Hackett, 1985), and low mathematics self-efficacy is linked to low self-concept and high mathematics anxiety (Jameson & Fusco, 2014).

Mathematics anxiety, a fear of mathematics, is not a belief but a result of negative mathematics instructional experiences (Jameson & Fusco, 2014) and beliefs (Beilock & Maloney, 2015; Carey et al., 2016; Cargnelutti, Tomasetto, & Passolunghi, 2017; Ferguson, Maloney, Fugelsang, & Risko, 2015; Jameson & Fusco, 2014), and this construct has been linked to negative mathematics behaviors (Sloan, 2010; Stoeck, 2017). Mathematics anxiety can lead to parents transferring their anxiety and negative mathematics beliefs to their children, reducing their children's mathematics performances (Geist, 2015; Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015; Schaeffer, Rozek, Berkowitz, Levine, & Beilock, 2018). For example, Maloney and colleagues' (2015) study of parents of first and second grade students found that students with parents with high mathematics anxiety learned less mathematics and experienced an increase in mathematics anxiety by the end of the school year. Schaeffer et al.'s (2018) study about high-math anxious parents of first- to third-grade students found that parent mathematics anxiety was negatively associated with their children's mathematics achievement. Specifically, their children learned approximately five months less of mathematics than students with parents with low mathematics anxiety.

Those with mathematics anxiety, as a result of negative instructional mathematics experiences and beliefs, often avoid participating in activities (Crafter, 2012a; Ginsburg, Rashid, & English-Clark, 2008; McMullen & de Abreu, 2011) that could improve their skills (Ashcraft, 2002) and help them assist their children with their homework (McMullen & de Abreu, 2011). Parents who report mathematics anxiety and negative instructional mathematics experiences and beliefs are also less likely to provide mathematics-enriching environments for their children

compared to parents who express positive beliefs about mathematics (Drešar & Lipovec, 2017; Jorgensen, Gates, & Roper, 2014). Therefore, as a result of the reciprocal relationship between negative experiences, beliefs, and anxiety, mathematics avoidance can limit student exposure to mathematics and reduce their learning opportunities (Crafter, 2012a; Drešar & Lipovec, 2017; Ginsburg et al., 2008; Jorgensen et al., 2014).

**Mathematics self-efficacy.** Self-efficacy plays a significant role in guiding one's motivation and engagement in specific behaviors (Bandura, 1986). Specifically, those with high levels of mathematics self-efficacy are more inclined to (a) create challenging goals, (b) view challenges as opportunities to master, (c) increase the effort required to master goals, and (d) associate failure with insufficient effort (Williams & Williams, 2010). Thus, mathematics self-efficacy's connection to overcoming educational obstacles (Jameson & Fusco, 2014) likely explains why high levels of mathematics self-efficacy correlate with higher mathematics achievement (Williams & Williams, 2010). High levels of mathematics anxiety, a construct that is closely linked to negative mathematics behaviors (Crafter, 2012a; McMullen & de Abreu, 2011), correlates with low levels of mathematics self-efficacy (Jameson & Fusco, 2014), a construct connected to individuals overcoming obstacles (Williams & Williams, 2010). For instance, McMullen and de Abreu (2011) interviewed mother-teachers and mothers who were not teachers of second through fifth-grade students and found that those who reported low confidence in mathematics generally devalued the importance of mathematics and were disengaged from learning new mathematics methods that their children were learning. Thus, increasing the mathematics self-efficacy of parents appears to be an effective strategy for improving their ability to learn standard-based strategies and apply them to their child's learning.

### **Mathematics Knowledge for Teaching**

Mathematics competence influences the role parents play in reinforcing mathematics instruction, and De Corte, Verschaffel, and Depaepe (2008) identified required elements of mathematics competence: (a) positive mathematic beliefs, (b) specific mathematical knowledge, (c) heuristic methods, (d) metacognition, and (e) self-regulatory skills. De Corte et al. (2008) reported that positive mathematics beliefs include self-concept and self-efficacy. Specific mathematical knowledge involves one's understanding of mathematical facts, symbols, procedures, concepts, and rules, and heuristic methods include strategies that can make solving easier. Metacognition is an awareness of one's motivation and cognitive abilities, and self-regulatory skills involve the ability to control one's behavior and problem-solving abilities.

The next sections described one major component of mathematics competence, mathematics knowledge for teaching. Mathematics knowledge for teaching is divided between subject matter knowledge and pedagogical content knowledge, two dimensions originating from Ball et al.'s (2008) MKT framework, which is based on Shulman's (1986) pedagogical content knowledge (PCK) construct that emphasizes the connection between knowledge of a subject and the ability to teach that subject. Within these dimensions are six domains: (a) common content knowledge (CCK), (b) horizon content knowledge (HCK), (c) specialized content knowledge (SCK), (d) knowledge of content and students (KCS), (e) knowledge of content and curriculum (KCC), and (f) knowledge of content and teaching (KCT). CCK, HCK, and SCK fall under subject matter knowledge, and KCS, KCC, and KCT fall under pedagogical content knowledge, which are outlined in the sections below.

**Knowledge of content.** Knowledge of content consists of different types of subject matter knowledge (Ball et al., 2008). CCK is a knowledge of mathematics that is not reserved for educators, but used by others in their own contexts (Ball et al., 2008), and it is analogous to

specific mathematical knowledge, which is an understanding of the basic components of mathematics (e.g., mathematical facts, symbols, procedures, concepts) (De Corte et al., 2008). International assessments such as PIAAC demonstrated that U.S. adults have limited CCK, with a below average score ranking of 17 out of 22 Organization for Economic Cooperation and Development (OECD) nations (National Center on Statistics [NCES], 2014). Sixty percent of U.S. adults scored below the basic numeracy level on PIACC (Ginsburg, 2017). Furthermore, Geary (2013) reported that 22% of the U.S. adult population is innumerate.

Prior knowledge is a requirement for deep learning and retention (Gee, 2008), and parents, who do not have solid mathematics foundations, often have difficulty grasping standards-based strategies (Jay et al., 2018). CCSSM emphasizes standards-based strategies that develop a concrete understanding of mathematics and critical thinking skills through varied strategies and tools (CCSSO & NGA, 2019). In contrast, parents learned mathematics that emphasized procedures and rote learning (Ginsburg et al., 2008; Jackson & Remillard, 2005; Remillard & Jackson, 2006), and they typically help their children with homework based on how they learned mathematics (Civil, Diez-Palomar, Menendez, & Acosta-Irqui, 2008; Horvat & Baugh, 2015). Thus, discrepancies in school and home instruction can impede parents' abilities to reinforce school instruction even when they are proficient problem solvers in their daily lives (Goldman & Booker, 2009; Remillard & Jackson, 2006). For example, Goldman and Booker's (2009) ethnographic study demonstrated that parents regularly performed complex mathematics tasks like performing accurate mental calculations for prom dress prices, but due to insufficient support, expressed difficulty in connecting school math to everyday mathematics. Remillard and Jackson's (2006) study about parents revealed that many were skilled in the mathematics they used daily (e.g., opening up bank accounts, measuring medication), but limited access to

resources, like textbooks and unfamiliarity with standards-based instruction, reduced their ability to provide mathematics support.

HCK is beyond what one teaches because it involves understanding how mathematics is connected at different grade levels to prepare students for what they will need to know for the future (Ball et al., 2008). In general, mathematics competence often requires practice whose meaning is socially constructed and reflects the learner's everyday experiences (Gonzales et al., 2001). Many parents, however, are unfamiliar with standards-based strategies (Goldman & Booker, 2009; Jay et al., 2018; Marshall & Swan, 2010; Remillard & Jackson, 2006), which are based on a progression of skills and concepts from previous years (CCSSO & NGA, 2019). Furthermore, SCK, a knowledge of mathematics that educators specifically use (Ball et al., 2008), appears difficult to develop without sufficient CCK.

**Knowledge of teaching.** Knowledge of teaching or pedagogical content knowledge consists of KCS, KCC, and KCT (Ball et al., 2008). KCS involves knowing how students learn about mathematics. KCC is one's general idea of a mathematics course and its associated materials and concepts, and KCT is about knowing instructional practices and mathematics (Ball et al., 2008). These three components of pedagogical content knowledge require a strong understanding of mathematics (Ball et al., 2008) that many adults do not have (Geary, 2013; Ginsburg, 2017). Westenskow, Boyer-Thurgood, and Moyer-Packham (2015) noted how parents need substantial support for reinforcing standards-based strategies. When parents received support and observed firsthand the effectiveness of these methods on their children's learning, they were likely to use these instructional strategies with their children. With guidance, parents can connect school mathematics to everyday life to extend their child's mathematical learning



(Goldman & Booker, 2009; Gonzales et al., 2001; Jay, Rose, & Simmons, 2013; Remillard & Jackson, 2006), but CCK is a prerequisite for teaching mathematics (Ball et al., 2008).

### **Mesosystem: Parent-Teacher Communication**

Bronfenbrenner's (1994) EST demonstrates different levels of direct interactions among the child's microsystems. The interactions between parents and educators are mesosystemic factors. The next sections described how role construction and access to resources influence parent-teacher communication.

#### **Role Construction**

Hoover-Dempsey et al. (2005) reported that role construction, parent beliefs about their responsibilities for student achievement, and self-efficacy are important factors that motivate parent involvement. School environments can increase parent self-efficacy and role construction across multiple demographics (e.g., SES, race, grade level, and the type of educational program for students) to promote parent involvement (Hoover-Dempsey et al., 2005). Role construction influences how parents interact with teachers, and misunderstandings between teachers and parents about their roles are obstacles for parents in developing their children's mathematical abilities. Price-Mitchell's (2009) meta-analysis on parent and teacher relationships identified behavioral patterns of schools where they prioritize increasing parent participation (e.g., volunteering, PTA participation) instead of developing parent-teacher partnerships. Thus, as teachers engage in one-way communication with parents, without inviting parent contributions to the dialogue, teachers lose valuable information that parents could have provided to support their child's learning in the classroom (Price-Mitchell, 2009).

Wilder (2017) reported that another obstacle to parent participation involved conflicts in how teachers and parents viewed their roles in developing student mathematics abilities. Some teachers wanted to maintain their role as the primary educator due to differences in their

instructional expertise (Epstein & Becker, 1982; Wilder, 2017). Wilder's (2017) pilot study about parents and teachers of kindergarten through third-grade students found that approximately 50% of parents wanted to share equal responsibility for instruction, compared to the majority of teachers, who wanted to maintain the primary responsibility of reinforcing instruction. Other teachers did not want to include parents who may challenge their authority (Epstein & Becker, 1982; Lareau & Horvat, 1999; Lasater, 2016). Lareau and Horvat's (1999) case study about the interactions and relationships among a majority White faculty and Black parents and students at a predominately low-income elementary school found that the teachers spoke positively about deferential parents who did not challenge them. However, many parents justified their distrust of their children's teachers, who rarely acknowledged their children's cultures and appeared to discipline Black male students more often than White male students for the same behaviors.

Teacher resistance to increasing parent involvement is inconsistent with the need to address an increasing number of instructional obstacles (e.g., curriculum changes, large class sizes, the implementation of new approaches), and teachers could benefit from additional support (Wilder, 2017). Some teachers prefer to be the primary contributors to student learning, while some parents view themselves as coequal partners that share instructional responsibilities (Wanat, 2010; Wilder, 2017). Some teachers report assigning parents more responsibility, while some parents report assigning teachers more responsibility (Lawson, 2003; Mattenucci & Helker, 2018; Peterson et al., 2011).

Differences in SES between teachers and parents can complicate parent self-efficacy and role construction (Lawson, 2003; Wanat, 2010), ultimately influencing how parents participate in their child's learning. Doucet (2008) reported that parents of low SES could offer valuable information about their children, but they were less likely to view themselves as coequal

partners. In contrast, Wilder (2017) found that parents of high SES were more likely to view themselves as coequal partners. Furthermore, Lareau (2003) demonstrated that middle-class parents, regardless of race, took charge to extend their instructional roles. They communicated with teachers to ensure they met their children's needs as opposed to working-class parents, who rarely communicated with teachers (Lareau, 2003). Middle-class parents were able to transfer their social capital to their children's academic development (Lee & Bowen, 2006). For example, Black parents from middle-class backgrounds skillfully interacted with teachers to peacefully extend their child's academic interests while protecting them from suspected racism in the school (Lareau, 2003; Lareau & Horvat, 1999).

Schools often reward middle-class parents, who make requests of their child's teachers that stem from their belief that teachers and parents are coequal partners (Lareau, 2003; Lareau & Horvat, 1999). In contrast, many teachers are critical of working-class parents' levels of involvement (Crozier, 1999; Lareau, 2003). Working-class parents' involvement often stems from their beliefs that intervening on behalf of their children is not their responsibility, due to a lack of academic knowledge and confidence (Crozier, 1999; Lareau, 2003). Thus, parents of low SES report resisting engagement, perceiving that teachers do not want their opinions (Lawson, 2003; Wanat, 2010). In addition, many parents, particularly African American parents, believe their roles extend outside school-based learning to prepare their children for racism and injustice (Doucet, 2008; McGee & Spencer, 2015), providing evidence of the complications race brings to role construction.

Research on school efforts to engage parents in ways that address differences in cultural background and social status is rare (Crozier, 1999). Therefore, school programs often do not address the specific needs of their parent populations, which in turn reinforces the parents' roles

as secondary stakeholders and reduces their motivation to participate in school-based events (Crozier, 1999). Researchers suggest that schools should transition from promoting parent involvement to promoting parent engagement (Goodall & Montgomery, 2014; Price-Mitchell, 2009; Stefanski, Valli, & Jacobson, 2016), which Price-Mitchell (2009) defined as parents sharing power with educators, instead of parents participating only when teachers invite them. Everyone has the capacity to teach (Ball & Lozani, 2009), and parents and teachers working together can transform education to solve problems that plague classrooms, such as reduced student motivation (Price-Mitchell, 2009). Using a systems perspective that focuses on problems from the whole (Shaked & Schechter, 2013), developing a holistic view of relationships between teachers and parents with a coequal relationship can increase student achievement (Price-Mitchell, 2009).

## **Resources**

Acknowledging and rewarding other forms of parental involvement that are not school-centric can increase motivation for parent involvement (Lee & Bowen, 2006), but many schools do not sufficiently address out of school learning (Jackson & Remillard, 2005), which firmly connects to cultural factors (Gillanders, McKinney, & Ritchie, 2012; Lawson, 2003). Educators have been successful in supporting parents' understanding of mathematics when they went outside traditional methods (e.g., parent-teacher conferences, PTA meetings). For example, teachers who have asked parents for what they need have tailored their instruction to meet their needs (Lee & Bowen, 2006; Mistretta, 2017). Mistretta's (2017) study demonstrated how parent feedback helped educators create interactive homework that aided the parents' understanding of reform strategies. Other studies demonstrated how events, such as workshops and mathematics nights, were also effective in developing parent understanding of reformed strategies (Gillanders

et al., 2012; Jay et al., 2013r). Panaoura (2017) also used Adobe Connect and Facebook to communicate with parents to increase their child's perseverance in problem solving. Furthermore, Berkowitz et al. (2015) demonstrated that providing resources, like an iPad app, can improve parents' abilities to reinforce school mathematics by reducing their mathematics anxiety. Teachers generally do not use varied and different types of resources to aid home communication and instruction, and thus parent participation has been limited (Angus, 2012; Ginorio & Huston, 2002; Gonzalez & Jackson, 2013; Lareau, 1987).

### **Exosystem: Teacher Preparation**

Pre-service teaching programs and teacher in-service professional development are exosystemic elements that indirectly impact student mathematics learning. Preservice teaching programs provide initial certification for those seeking to teach, whereas teacher in-service programs provide practicing teachers opportunities to enhance and improve their teaching. Pre-service teaching programs and the first references to teacher in-service professional development specifically addressed the obstacles teachers have in communicating with parents. Educational policy is another factor existing at the exosystem level that also consists of teacher in-service professional development and school involvement. The secondary references to teacher in-service professional development addressed how professional initiatives influence teachers' abilities to implement the CCSSM.

### **Instructional Development**

Insufficient support for teachers on how to effectively engage parents is an obstacle that parents encounter when reinforcing mathematics instruction. Teacher professional development on parent involvement is not established (Marschall, Shah, & Donato, 2012), and pre-service teacher programs rarely reference parent involvement (Chavkin & Williams, 1988; Lasater, 2016; Marschall et al., 2012). These factors, in turn, influence parent-teacher communication

because many teachers have received minimal training on how to communicate with parents to extend their instruction (Mistretta, 2017) and cultivate partnerships with parents (Doucet, 2008; Epstein, Galindo, & Sheldon, 2011; Hoover-Dempsey et al., 2002). Mistretta's (2017) study on teacher-family communications regarding mathematics found that although 94% of teachers in their initial questionnaire responses were concerned about limited family involvement, 100% of teachers exhibited a "passive mindset towards family members" (p. 191). All teachers noted how they would provide family support by sending information home for them to read, and 61% stated their intention of meeting with families to disseminate information containing lists on mathematics concepts. These examples demonstrate their intent to provide information but not provide instructional supports to help parents engage their students in the learning process to promote high-level thinking about mathematics.

U.S. schools are becoming more diverse while the teaching profession remains predominately White (National Center for Education Statistics [NCES], 2010), and inadequate development on cultural competency can further limit parent-teacher communication. For example, Gomez and White (2010) demonstrated how pre-service teachers' knowledge about other cultures stemmed not from their training, but from painful experiences they learned through their negative and prejudicial interactions with people of other races. One pre-service teacher recalled her astonishment at hearing a Black student refer to her as a racist when the student introduced her to a family member. The pre-service teacher was unaware of how her interactions with students were negatively perceived until the student explained that her references to Black students were mostly negative, in contrast to the White students.

Effective pre-service preparation programs and teacher professional development require a focus on cultural competency (Gay, 2010), which is the knowledge and orientation that enables

teachers to effectively engage others from diverse backgrounds (Milner, Flowers, Moore, Moore, & Flowers, 2003). For example, Ladson-Billings' (1995) study identified eight exemplary elementary-school teachers of Black students based on parent interviews. She triangulated parent responses based on principal and colleague feedback and her observations and found that parents accurately identified excellent teachers, who not only instilled in their children a love of learning but expressed respect toward the parents. She also determined that culturally responsive instruction facilitates family member involvement, like presenting their professions to the class. Gonzalez et al.'s (1995) study demonstrated how teachers who conducted ethnographic research at their Latino students' homes in order to embed their cultures into their instruction established trust and relationships with families. These relationships empowered parents to view themselves as instructional resources, who no longer felt the school environment to be inaccessible and impenetrable.

Understanding culture and the role of privilege is an important lesson for preservice and in-service teachers. Pre-service programs that address culture and equity include activities and experiences that can challenge and change teacher candidates' stereotypical views toward students using strategies. In addition, programs that go further and include parent engagement have an even greater potential for building cultural sensitivity in their candidates.

Sufficient pre-service teacher programs can dismantle teacher candidates' stereotypical views of low-income and minority students using various means (e.g., self-reflection exercises, student-led conferences) to increase parent engagement (Amatea, Cholewa, & Mixon, 2012). Moreover, teacher invitations for parent participation are strong predictors of parent involvement when they address specific parent needs and acknowledge the unique skills that parents bring to their children's learning (Deslandes & Bertrand, 2005; Epstein, 1991; Hoover-Dempsey, Bassler,

& Burow, 1987; Hoover-Dempsey et al., 2005). According to Lee and Bowen's (2006) nationally-representative study that included third-, fourth-, and fifth- grade students and their parents, parent involvement differed based on demographics. For example, Black parents, Latino parents, and parents of low SES were the most involved at home and less involved in school settings, while parent involvement in school settings was highly correlated with high student achievement. White parents whose children did not require free and reduced meals, the demographic most likely to match the teaching population, were most likely to attend school functions, suggesting an advantage for obtaining information when school invitations for parent involvement often require their attendance at school functions. Thus, pre-service teaching programs and teacher in-service professional development that addresses cultural proficiency and effective ways to communicate with parents may increase teacher-parent communication to reduce obstacles to parent mathematics engagement.

### **Educational Policy**

Overall, teachers are considered instrumental to student learning, and policymakers have dedicated more time and effort to improving teacher development (Ball & Forzani, 2009). Additionally, teacher mathematics knowledge and their perspectives impact the effectiveness of their instruction (Ball, 1991; Ernest, 1989; Wilkins, 2008). According to Wang and Lin (2005), the United States has tried to reform mathematics practices by developing new curricula about teaching standards that improve teaching and change the way teachers engage in developing their instructional practices. Standards-based mathematics, however, have challenged many teachers' perspectives on instruction (Rousseau, 2004; Wilkins, 2008) with its emphasis on multiple solutions (Silver et al., 2005) and inquiry-based learning (Hunter, 2010). Thus, many teachers are unprepared for these instructional changes (Silver et al., 2005), and there is a need for sustained



in-service development on standard-based mathematics strategies, mathematics content, and student thinking about mathematics (Wei, Darling-Hammond, Andree, Richardson, & Orphanos, 2009).

Another obstacle is that while many teachers struggle with policymakers' mathematics reforms, there is little empirical evidence to guide professional development programs (Bell, Wilson, Higgins, & McCoach, 2010). Ball and Forzani (2009) noted that there is a bias against professional development that is detailed and specific (e.g., incorporating coaching and direct observation and supervision of teachers), and argued that this type of professional development is required for improving teacher instruction. Furthermore, the instructional expertise that empowers teachers to make suggestions for improving curricula (Charalambos & Philippou, 2010) typically occurs when they receive adequate and sustained professional development and support (Tunks & Weller, 2009), which many do not receive (Wei et al., 2009). Ball and Forzani (2009) also argued that teachers do not naturally develop skills for exemplary instruction. Therefore, in-service programs should include specialized, highly-detailed training that focuses on the practice of teaching instead of knowledge (Ball & Forzani, 2009).

The wide scope of what teacher professional development needs to address further complicates the effectiveness of these programs because they should include practicing teaching methods, learning from master teachers, analyzing task examples, observing master teachers in action, and teachers receiving supervision (Ball & Forzani, 2009). Ma's (1999) comparative study demonstrated the importance of effective professional development on instruction, suggesting that China's superior performances to U.S. performances on international assessments stemmed from how Chinese teachers are allotted more time than U.S. teachers on lesson preparation and understanding the concepts they teach. This additional preparation appeared to

deepen their conceptual and procedural knowledge of mathematics (Ma, 1999).

Many school districts do not have the capacity to adequately implement educational reforms (Bryk, Gomez, Grunow, & La Mahieu, 2015). As a result, many educators, the primary implementers of curriculum (Charalambous & Philippou, 2010), are not prepared to teach students (Silver, Ghouseini, Gosen, Charalambous, & Strawhun, 2005) and communicate curriculum changes to parents (Chavkin & Williams, 1988; Marschall et al., 2012; Mistretta, 2017). These obstacles have left teachers largely unprepared to help parents assist their children with mathematics learning.

Policymakers have generally excluded parents from the discourse and implementation of the CCSSM (Remillard & Jackson, 2006; Schoenfeld, 2004). According to Remillard and Jackson (2006), “Parents were framed in a corpus of policy documents [NCTM documents] as being mathematically incompetent to support their children’s learning or as uninterested in doing so” (p. 233). Deficit perspectives such as these informed educational policies resulting in the exclusion of parent involvement (Remillard & Jackson, 2006), thus impeding their reinforcement of school instruction (Goldman & Booker, 2009; Lawson, 2003; Marshall & Swan, 2010; Remillard & Jackson, 2006). Insufficient teacher training programs have further exacerbated parent barriers, as these programs rarely address parent involvement and how to communicate effectively to help parents extend their child’s mathematics learning. The implementation of the CCSSM has also resulted in educators, who have not received adequate professional development on standards-based reforms to communicate these changes to parents, who are generally unfamiliar with standards-based strategies.

### **Macrosystem: Culture**

The macrosystem includes culture, which incorporates many components that play a role

in parent mathematics involvement: race, SES, gender, and national origin. Race distinguishes between groups based on ancestry and shared physical characteristics (Edwards, Fillingim, & Keefe, 2001). SES involves a multitude of factors, like household income and the parent's level of educational attainment (Rajan et al., 2015). Gender involves the influence the child's gender has on parent mathematics assistance. National origin addresses the influence of where parents were born and raised on their mathematics engagement.

## **Race**

White teachers make up 83% of teachers in the United States (National Center for Education Statistics [NCES], 2010). As a result, schools generally represent customs that favor White, middle-class students, resulting in cultural differences that occur when schools fail to reflect and engage minority and low-income student populations, and by extension, their families (Angus, 2012; Ginorio & Huston, 2002; Gonzalez & Jackson, 2013; Lareau, 1987). Ginorio and Huston (2002) noted differences between Latino culture and school culture that affected their ability to successfully navigate the school environment. For example, some poor Latino families did not connect school behaviors to school achievement (e.g., school attendance) when schools often assumed they were aware of these behaviors. Latino families also generally promoted cooperation among family members, while schools generally promoted competition among students.

Cultural divides also occur because many schools hold events in school settings and equate school-based involvement (e.g., volunteering, PTA meeting attendance, parent-teacher conference attendance) with parent interest and involvement (Bower & Griffin, 2011; Doucet, 2008; Lee & Bowen, 2006; Stevens & Patel, 2010). When schools promote school-centric programs, programs that require face-to-face involvement, they fail to define other ways

minority and low-income parents participate in their children's learning (Bower & Griffin, 2011; Gillanders et al., 2012; Jackson & Remillard, 2005; Lawson, 2003). Many Latino, African American, and low-income parents are highly involved with their child's learning at home (Doucet, 2008; Jackson & Remillard, 2005; Lee & Bowens, 2006; Wanat, 2010). Regarding limitations to in-school involvement, some parents cited work schedules that conflict with scheduled school activities (Lawson, 2003) and the perception of inferiority projected from school officials toward parents (Bernhard, Lefebvre, Kilbride, Chud, & Lange, 1998). The emphasis on face-to-face parent involvement often results in school officials excluding parents due to their inability to attend school functions (Lawson, 2003).

Teachers who perceive parents as less interested and involved in their child's learning, due to their absence at school events, are less likely to implement programs for parents (Crozier, 1999; Stevens & Patel, 2010) and more likely to negatively judge them (Bower & Griffin, 2011; Crozier, 1999; Doucet, 2008; Gillanders et al., 2012; Hill & Torres, 2010; Lawson, 2003). Lareau and Horvat (1999) suggested that African American parents' home involvement contrasts with the expectation for in-school parent engagement, which in turn perpetuated the belief that African American parents do not care about education. Thus, the lack of participation in school events and the negative judgments that result, perpetuated a cycle of mistrust and limited parent engagement (Lawson, 2003) when the ineffectiveness of school programs often account for low parent involvement (Epstein & Dauber, 1991).

## **Gender**

Schools that do not consider parental participation outside of school-based involvement limit their ability to address other parent influences, such as academic socialization, how parents communicate the importance of education and set academic expectations for their children

(Bhargava & Witherspoon, 2015). Some parents may have gender-stereotyped views about male students having higher mathematics abilities than female students (Gunderson, Ramirez, Levine, & Beilock, 2012). Gender stereotypes can influence how children perceive their abilities (Denner, Laursen, Dickson, & Hartl, 2016; Tiedemann, 2000), negatively affecting their mathematical performances (Alperone, Cadinu, & Tomasetto, 2011). Furthermore, Wood, Kurtz-Costes, Rowley, and Okeke-Adeyanju (2010) reported that African American mothers might contribute to the gender gap in African Americans' academic achievement because of lower standards for their sons' academic futures than their daughters'.

Schools that equate an increase in parent involvement with higher perceived competence for all students (Denner et al., 2016) may fail to realize that different parental expectations affect behaviors that can reduce student confidence and achievement (Bhargava & Witherspoon, 2015). Parents who believe gender stereotypes are more likely to limit their daughters' mathematics opportunities, such as purchasing more mathematics games for sons and allowing less time for daughters to finish their mathematics work (Galdi, Mirisola, & Tomasetto, 2017). Denner et al. (2016) found that Mexican mothers, who hold gender-stereotyped views, are less likely to help their daughters with mathematics but are more likely to help their sons.

## **SES**

The inability of schools to effectively address SES factors can diminish parent abilities to reinforce school instruction (Greenman, Bodovski, & Reed, 2011). Low-income neighborhood factors (e.g., poverty, crime) diminish parent expectations and aspirations for their children, limiting their ability to effectively engage in their children's mathematics learning (Greenman et al., 2011), and thus, decrease student mathematics achievement (Anderson, Leventhal, & Dupéré, 2014; Pearman, 2017). Parents' capacity to access resources can greatly influence their

participation in their children's learning (Lee & Bowen, 2006; Yoder & Lopez, 2013). For example, the lack of access to technology is a common problem for low-income families (Hick, 2006). Parents have limited access to information that could help them complete their homework, while schools are expanding their digital capabilities (Hick, 2006; Yoder & Lopez, 2013). Hick (2006) determined that the challenges for policymakers will be in closing the digital gap for low-income communities by creating community technology centers (CTCs), facilities where citizens can access free computers. Schlee, Mullis, and Shriner (2009) also reported that parent social capital and resource capital (financial capital) create class divisions in student performances. Furthermore, Greenman et al.'s (2011) findings align with Schlee et al.'s (2009) argument that the combination of family characteristics in disadvantaged neighborhoods reduces educational activities for children and mathematics achievement for elementary school students.

Parents with greater access to resources can also contribute to the widening of academic gaps (Jorgensen et al., 2014), specifically in mathematics, which is a "badge of eligibility for the privileges of society" (Atweh, Bleicher, & Cooper, 1998, p.63). Jorgensen et al. (2014) argued that even mathematics school instructional practices (e.g., separating students by ability level, using language that favors students of higher SES) perpetuate academic gaps across different social classes. For example, in contrast to low-income families, middle-class families often use signifiers such as "more" or "less." Thus, middle-class students are better prepared for mathematical conversation that involves students identifying numbers that are more or less than others (Jorgensen et al., 2014). Families of higher SES also deliberately develop their children's *mathematical capital*, resources leveraged to maintain mathematical success, using mathematics games that align with school instruction (Williams & Choudry, 2016). Concerted cultivation is when parents promote their children's involvement in organized activities (e.g., museum trips,

scouting, dance recitals) that result in sustained academic advantages (Cheadle, 2008; Lareau, 2003). However, low-income parents are typically unable to engage in concerted cultivation, limiting their ability to reinforce instruction (Cheadle, 2008; Lareau, 2003). Cheadle (2008) also reported that concerted cultivation correlated with increases in Latino and Caucasian students' mathematics performances during the school year, suggesting that more research should examine the impact schools have on exacerbating, perpetuating, or closing racial achievement gaps.

Parents from low SES often encounter challenges when leveraging social supports and networks than wealthier families (Yoder & Lopez, 2013). Their neighborhoods tend to have disintegrated social orders (Leventhal & Brooks-Gunn, 2000) that result in violence and crime that further reduce support among families and their access to resources (Lawson, 2003; Sampson, 1997; Sampson & Groves, 1989). Low-income neighborhoods greatly benefit from strong social networks and increases in social capital (Price-Mitchell, 2009; Wanat, 2012).

### **National Origin**

Schools can help parents by addressing obstacles to their involvement that are outside of parental control (Yoder & Lopez, 2013), such as cultural mismatches that occur between schools and parents because of differences in national origin. Turney and Kao (2009) found that immigrant parents reported that the primary obstacles to school involvement were language barriers and school environments that felt uninviting, while Klugman, Lee, and Nelson (2012) found that Latino immigrants reported that perceived barriers and not hearing about events that appeal to their interests, were their primary obstacles. Gillanders et al.'s (2012) study identified barriers to Black and Latino mothers' involvement in their children's elementary school. For example, they learned that school officials asked Latino parents, whose primary language is Spanish, to participate in activities presented in English, which in turn limited their engagement.

These researchers also found that meeting with mothers helped them identify their specific needs and ways to reduce barriers for supporting their children (e.g., support groups, mentoring programs for students, sports programs for students). Turney and Kao's (2009) longitudinal study on minority immigrant parents found that parents generally reported fewer obstacles the longer they lived in the United States, but Black immigrants<sup>1</sup> reported an increase in obstacles, suggesting that race and immigration status compound the problems parents experience in their school involvement. Marschall et al.'s (2012) examination of the National Center for Educational Statistics' Schools and Staffing surveys reported that minority principals and an increase in cultural proficiency training for parent outreach were integral to the increased participation of immigrant parents. Marschall et al. (2012) reported that Black<sup>2</sup> and Latino principals, in particular, were very successful in engaging immigrant populations because their presence significantly correlated with more limited English proficiency programs that were geared to immigrant families' involvement.

Furthermore, schools cannot assume that the same school initiatives will meet the diverse needs of all immigrant parents because differences in SES may require school officials to communicate differently with parents within immigrant populations (Feliciano & Lanuza, 2017). SES factors, such as parent contextual attainment and levels of education that parents have completed, may account for why some racial immigrants outperform their native counterparts (Feliciano & Lanuza, 2017). Specifically, immigrant parents of high SES can overcome the barriers associated with immigrant status because they have "class specific resources" like high expectations that they can transfer to their children (Feliciano & Lanuza, 2017, p. 233).

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<sup>1</sup> Turney and Kao (2009) did not provide the specific ethnic groups for the participants in this study.

<sup>2</sup> Marschall et al. (2012) defined "Black" as African American.



SES status may influence the achievement of immigrant groups differently. Some studies illustrated how SES status has a weaker influence on some immigrant groups. Feliciano and Lanuza (2017) demonstrated that children of East Asian immigrants maintained an educational advantage in the amount of schooling they completed despite their parents' low SES upon emigrating to and living in the United States. Lee and Zhou (2017) demonstrated how the students of Chinese and Vietnamese immigrants with less than a high school education earned college degrees at almost identical rates as peers of middle-class status. Other studies demonstrated that SES has a greater influence on some immigrant groups. Haller, Portes, and Lynch (2011) and Kroneberg (2008) demonstrated that low SES in combination with other factors (e.g., treatment from the receiving country, occupations of previous generations) has a disproportionately negative impact on the academic achievement of Mexican and Afro-Caribbean students of immigrants. Thus, SES differences affect different immigrant populations at varying degrees, which in turn, complicates how schools interact with parents of different national origins.

Western beliefs regarding mathematics may also play a role in parent involvement. Many adults in western societies reveal that mathematics is one of their weaknesses (Wieschenberg, 1994) and have a deep-seated fear of mathematics that Burns (1998) notes many children are susceptible to adopting. These western beliefs are (a) mathematics competency is reserved for those gifted in the field, (b) mathematics is too difficult for normal people to learn, (c) strong mathematical competency is the ability to perform quick and accurate calculations, and (d) only one correct way exists for solving problems (Ashcraft, 2002; Johnston-Wilder & Lee, 2010; Wieschenberg, 1994). These misconceptions and the belief that failure in mathematics is “permanent, pervasive, and personal” (Wieschenberg, 1994, p.52) are obstacles to learning

mathematics (Ashcraft, 2002) and impede parent abilities to effectively engage their children in mathematics (Burns, 1998).

Wieschenberg (1994) confirmed Schoenfeld's (1989) findings in his study of high-performing students, tenth through twelfth grade, at three high schools. Student responses to questionnaires indicated that they believed that natural mathematic ability was essential for mathematics success. These students expected to solve homework and test questions in one to two minutes and considered problems impossible to solve if they required an average of 12 minutes to complete (Wieschenberg, 1994). Hsin and Xie's (2014) study of White American students and Asian American students found that the academic advantage of Asian Americans largely stemmed from their belief that hard work drives academic success. In contrast, the western perspective largely contends that cognitive ability is fixed and cannot be developed through hard work (Hsin & Xie, 2014). The Chinese saying goes, "Diligence compensates for stupidity," and this perspective provides Eastern cultures with a unique advantage for succeeding in mathematics (Leung, 2014). The cultural belief that mathematics abilities are unalterable in the United States, also known as a fixed mindset, is in direct opposition to the growth mindset, a belief that abilities can develop (Blackwell, Trzesniewski, & Dweck, 2007).

Consequently, East Asian adults and students view hard work as a requirement to compensate for limitations (Leung, 2014) as demonstrated by Chinese fourth graders (Tuss, Zimmer, & Ho, 1995) and Chinese eleventh graders (Fuligni & Stevenson, 1995), who attributed greater effort to mathematical success. Mindset can predict behavior and mathematics achievement, as Blackwell et al. (2007) demonstrated in their two-year study of middle school students, where students with a growth mindset showed improvements in mathematics grades

compared to those with fixed mindsets. Thus, a fixed mindset can result in low confidence when people believe failure is the only result (Howard & Whitaker, 2011).

### **Summary and Next Steps**

Bronfenbrenner's (1994) EST informed the examination of obstacles parents encounter to reinforcing their children's understanding of mathematics. At the microsystem level, parents' negative mathematics experiences and, thus negative mathematics beliefs and fears influence their ability to effectively participate in their child's mathematics learning. Conflicting beliefs about role construction and limited access to resources can also serve as impediments at the mesosystem level. Exosystemic factors, like teacher development programs and educational policies, also influence teacher learning opportunities and subsequently impact parent learning opportunities for helping their children. Cultural disconnects, located at the macrosystem level, can also impede parent reinforcement of school instruction.

These factors have influenced the ability of parents to reinforce mathematics instruction. However, there is little empirical research about parental beliefs and mathematics knowledge concerning standards-based instruction for upper elementary students. Therefore, the needs assessment objective was to examine the degree of influence these parent obstacles have and identify factors that can be improved to enhance parent ability to effectively engage in their child's mathematics learning.

## **Chapter Two**

### **Empirical Examination of the Factors and Underlying Causes**

Parents experience many obstacles to reinforcing mathematics instruction. Supporting parents through targeted strategies to provide structures and activities may help them better provide mathematical experiences outside of school. Parents who are better able to overcome school barriers are those with greater access to resources (Lareau, 1987, 2003), suggesting that these resources help bridge the gap between home knowledge and school knowledge. Therefore, the needs assessment objective was to determine the extent of parent need by examining the specific supports they desired and the mathematical knowledge they required to improve their abilities, beliefs, and self-efficacy levels. The following research questions (Table 2.1) guided the needs assessment study. Research question one served to identify the supports parents desire for improving their child's mathematics learning and engagement, and research question two involved identifying supports for improving parent attitudes and beliefs about how their children learn mathematics. Research question three was about identifying the supports for improving parent confidence with helping their children's mathematics learning, and research question four was about identifying the supports parents believe their children need for their mathematics development.

Table 2.1

*Needs Assessment Research Questions*

Research Question 1	What mathematics knowledge for teaching support do parents want to help their children learn and appreciate mathematics?
Research Question 2	What mathematics knowledge for teaching supports enhance parents' beliefs about their children learning mathematics?
Research Question 3	What mathematics knowledge for teaching supports enhance parent self-efficacy for developing their children's mathematics abilities?
Research Question 4	What mathematics knowledge for teaching supports do parents report as helpful for developing their children's mathematics abilities?

### **Context of Study**

The participants (N= 67) were parents of students in third, fourth, and fifth grade in an elementary school located in an ethnically diverse and affluent suburb. Additionally, approximately 93% of online parent participants earned either a bachelor's degree (N=21), a master's degree (N= 24), or a doctorate (N=12) as their highest level of educational attainment.

### **Method**

The sections below examined the primary needs assessment instrument, the survey (Appendix A). The next sections also described the needs assessment procedures. These procedures included emailing online surveys and conducting in-person interviews.

### **Instrumentation**

The needs assessment was a mixed methods study, a category of research that combines qualitative and quantitative research methods, techniques, and instruments (Johnson & Onwuegbuzie, 2004; Onwuegbuzie & Leech, 2006). Data collection occurred in the form of

surveys and in-person interviews, and the survey was a mixed methods instrument, consisting of questions (N=28) that were primarily open-ended (N=7) and close-ended Likert-scale items (N=19). The response scale for the close-ended questions was from one to four, ranging from *strongly disagree* to *strongly agree*, and the survey measured the following constructs: *beliefs about mathematics learning, mathematics self-efficacy, conceptual knowledge for helping my child, mathematics knowledge for helping my child, school-home communication and support, and parent characteristics.*

## **Procedures**

Several measures were taken to increase the survey's validity and reliability before the needs assessment study began. Questions were assembled by the researcher and reviewed by mathematics professors, who specialized in elementary mathematics instruction at the University of Kentucky (UK). Several revisions and thus iterations of the survey ensured that the final product sufficiently addressed the constructs and contained language that was clear and concise. To address the survey's reliability, a factor analysis on survey items was conducted. To strengthen the survey's validity, three cognitive interviews were conducted with parents, who were not involved in the study and whose primary language was not English, to ensure that the survey questions were easy to read and understand. These measures addressed the needs of the parent population, which was predominantly from other countries, where English is a secondary language.

**Online survey.** By email, the online survey reached all parents of children in grades three through five in the school. The online survey was available for three weeks, and 61 parents responded to the survey. Each parent had the opportunity to read a clause that assured their

confidentiality and the option of leaving the survey at any time. The survey was a Google Drive instrument that did not track parent emails, ensuring parent confidentiality.

**Interviews.** Six of the ten parents were contacted by email to request their participation in the study agreed to an in-person interview. To receive additional information from the school's large immigrant population, parents of Turkish and South and East Asian descent (e.g., Pakistani, Indian, Chinese) were interviewed. Each interview lasted approximately 30 minutes, and interviews occurred in the school's conference room (N=2), the researcher's classroom (N=1), and the participants' homes (N=3).

Parents of students who were not in the researcher's mathematics class were interviewed to reduce the likelihood of biased responses that could occur if the researcher was their child's mathematics teacher. Five of the students were the researcher's mathematics students, leaving 14 out of 30 students with parents that fit the criteria for interviews (e.g., the primary language is not English, parent of an upper-elementary student). Parent participants also read the survey's confidentiality clause, which provided the option of opting out of the interview, and numbered codes were used to maintain their anonymity.

After conducting interviews and collecting online participant surveys, graphs were created that differentiated online participant responses based on their professions. A thematic analysis of participant responses was conducted using emergent coding to triangulate quantitative results from the online survey and provide additional insight into participant responses. The next section contains a review of constructs, questions that measure these constructs, and an examination of how well the constructs and research questions align.

### **Needs Assessment Constructs**

The survey constructs were beliefs about mathematics learning, conceptual knowledge for helping my child, mathematics knowledge for helping my child, mathematics self-efficacy,

school-home communication and support, and parent characteristics. Beliefs about mathematics learning addressed parent attitudes about standards-based strategies and mathematics in general. Conceptual knowledge for helping my child determined parent readiness for assisting their child with standards-based strategies, which according to Goldman and Booker (2009) and Remillard and Jackson (2006) emphasize the use of multiple problem-solving approaches and tools. Mathematics knowledge for helping my child examined the participants' general mathematics knowledge, also known as specific mathematical knowledge (De Corte et al., 2008) or common content knowledge, as described in Ball, Thames, and Phelps' (2008) MKT framework. This construct identified whether parents had the foundational knowledge required for helping their child with mathematics. Mathematics self-efficacy examined parent confidence in developing their children's mathematics abilities. The study also examined school-home communication and support based on parent reports of the resources they received. The last construct, parent characteristics, examined participant background and their experience with mathematics in their professions. All construct items are found in Appendix A.

### **Beliefs about Mathematics Learning**

Sonnenschein et al. (2012) defined parental beliefs as attitudes about the "importance of children doing math [*sic*] activities at home, beliefs about how children learn, parents' roles in their children's learning, and parents' own math [*sic*] skills" (p. 4). Seven items from the needs assessment measured parental beliefs to address what they thought about standards-based mathematics. Thus, these survey questions align with research question two, which addresses the instructional supports that can improve parent beliefs for developing their children's mathematics abilities.

### **Conceptual Knowledge for Helping my Child**



Conceptual knowledge of mathematics is an understanding of mathematical concepts that allows one to connect concepts to algorithms and solve problems without algorithms (Crooks & Alibali, 2014). Standards-based instruction emphasizes developing a deep understanding of mathematics constructs and connections among those constructs through the use of multiple strategies and tools (CCSSO & NGA, 2019). Six survey items measured the ability to use multiple strategies that demonstrate connections among various mathematics concepts. These questions assessed the extent to which parents understood standards-based mathematics strategies, and the responses to these questions would inform the supports provided during the intervention. Therefore, these survey questions align to research question four, which is about parent perceptions of their ability to help children learn and appreciate mathematics.

### **Mathematics Knowledge for Helping my Child**

Ball et al.'s (2008) MKT framework described the type of knowledge required for effective mathematics instruction. The survey contains five items that addressed common content knowledge, "mathematical knowledge and skill used in settings other than teaching," and knowledge of content and teaching, "the knowledge of instructional practices and mathematics" (Ball et al., 2008, p. 399). These items measured a parent's ability to apply their understanding of foundational mathematics to develop their children's skills to identify sufficient instructional supports. Thus, these items align with research question four, which is about parent perceptions of their abilities to help their children learn and appreciate mathematics.

### **Mathematics Self-Efficacy**

Self-efficacy is the belief in one's abilities to influence life outcomes (Bandura, 1986, 1977; Bandura & Schunk, 1981), and mathematics self-efficacy is the belief that one will be successful in doing mathematics and performing mathematics tasks in general (Hackett, 1985).

The survey contains five items that measured mathematics self-efficacy, parent confidence in reinforcing mathematics instruction at home, and the extent to which they could assist their children's learning as they progress to higher levels of mathematics. Therefore, these questions align to research question three, which is about the school supports that could improve parent self-efficacy in helping their children learn mathematics.

### **School-Home Communication and Support**

The school-home communication and support items addressed interactions between the teachers and parents and the resources teachers provided the participants that help them support their child's mathematics learning at home. Four survey items addressed the level of assistance parents receive for extending their child's learning at home. Thus, these questions align with research question one about the supports parents want to help them reinforce mathematics instruction.

### **Parent Characteristics**

Two items addressed parent characteristics, which include parent levels of educational attainment and their occupations. Figures 2.1 through 2.6 also distinguish parent responses based on seven career categories: researcher/engineer, unemployed/homemaker, IT professional, professional, teacher, medical assistant, and business leader. Parent characteristics were measured due to their potential influence on participant responses to the four research questions.

## **Results**

### **Beliefs about Mathematics Learning**

Survey participants displayed positive attitudes about mathematics in their responses to items one through seven (Appendix A). One hundred percent of the parents agreed on the following: (a) their children should see mathematics every day (strongly agreed: 80.3% and agreed: 19.7%), (b) helping their children was important (strongly agreed: 82% and agreed:

18%), (c) it was important for their children to like mathematics (strongly agreed: 77% and agreed: 23%), and (d) learning concepts was as important as understanding algorithms (strongly agreed: 44.3% and agreed: 55.7%). Sixty-eight and nine-tenths percent of parents (strongly agreed: 19.7% and agreed: 49.2%) responded that current mathematics instruction is more effective than how they were taught. In addition, 93.5% of parents (strongly disagreed: 24.6% and disagreed: 68.9%) disagreed that memorization was more important than understanding. On average, 93.7% of the online participants, those who responded to the surveys online, reported having positive views about current mathematics instruction.

Furthermore, there were no meaningful differences in beliefs between the different professions. For example, scores for all professions fell at items four (BLM4) and five (BLM5R), which addressed if parents believed the way students learn mathematics today is more effective than the way they were taught and whether mathematics was more about memorization than understanding.

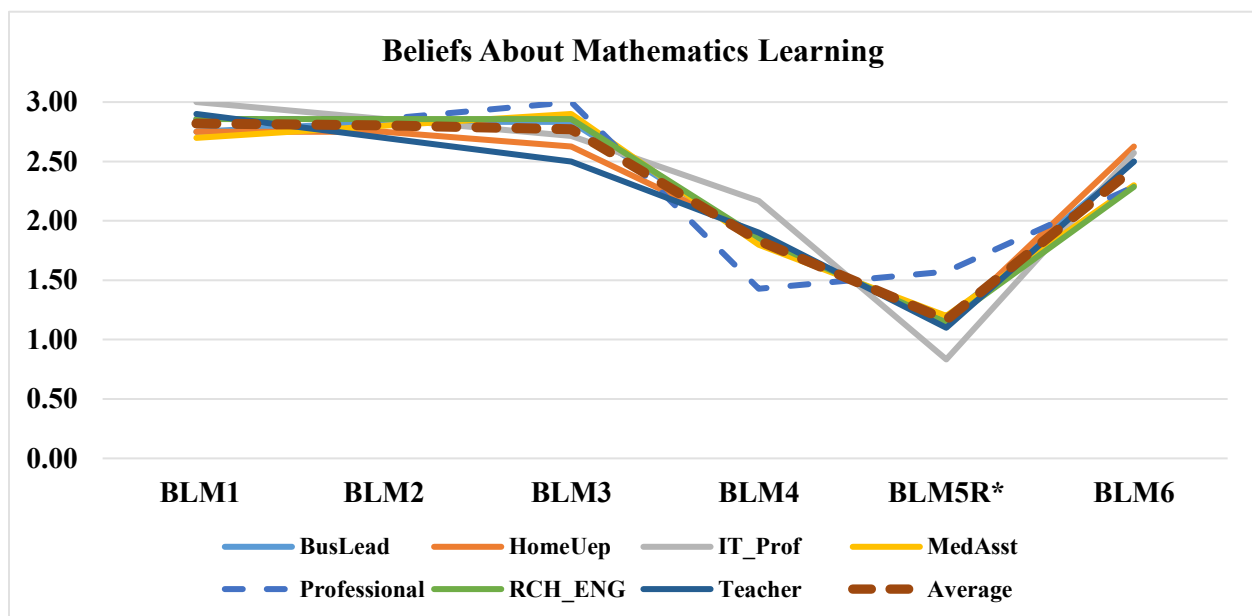


Figure 2.1. Beliefs about Mathematics Learning graph

The following themes emerged, *instructional differences*, *efficiency*, and *usability*, in the examination of participant beliefs. Many participants noted differences in how they learned mathematics compared to how their children are learning mathematics. Participants also recommended that instruction make efficiency a priority in addition to developing student understanding of mathematics strategies. The importance of the strategies' usability was stressed regarding real-life application.

The code *new mathematics* was identified to represent the theme of instructional differences as participants discussed the differences between how they learned mathematics and how their children are learning mathematics. One online participant responded, "We were taught to memorize the formula to get the correct answer. I can see that this way of multiple manipulatives and place value has helped my boys understand better." Another participant wrote, "Understanding the rules before memorizing them is more important than just memorizing the rules," and a third participant responded, "My child seems to be learning the concepts of math [*sic*] rather than memorizing specific, rigid ways to solve math [*sic*] problems. I like how the school/county is approaching math [*sic*] with my child versus the way I was taught." Another participant responded:

We all are aware that mathematics is taught differently now with the Common Core, but I don't think the new way is that hard (as people have complained) - I think both ways have valuable aspects and exposure to multiple ways of solving problems is essential for learning!

An interviewee stated that current instruction, "Showed how to solve in real life as opposed to just solving...better to understand."

The descriptive code *refocus* was identified from which the theme of efficiency emerged as participants noted how they wanted instruction to highlight other areas of mathematics than the strategies students currently used. Many participant comments indicated a desire for current mathematics instruction to broaden its focus to efficiency, suggesting that instruction that emphasized multiple strategies would not lead to students learning efficient strategies. While some parents appeared to appreciate the necessity of multiple approaches, many also thought mathematics instruction should lead to efficient and familiar algorithms. One participant stated, “While I agree that it is important to teach the children different ways and methodologies, it is also important to highlight and direct the students towards more efficient ways of performing an operation.” Another participant wrote, “Understanding math concepts is important but so is memorization. It can’t be an either or, it needs to be both,” while another participant stated, “I think understanding math basics is the most important thing.” One respondent stated, “Concepts versus procedures is tough. I think the student needs both,” while another participant reiterated a similar idea, “Conceptual learning should be combined with faster efficient solving methods.” Another wrote, “The new math is cool, but can’t we teach some of the old ways too? And memorizing times tables was never a waste of time.”

The code *real-life application* reflects the theme of *usability* as parents discussed how standards-based strategies appeared less useful in real-world settings. One participant stated, “Kids should also learn math that is applicable to life such as calculating percentages, counting money, and finding pricing and which prices give more value for the dollar.” Another participant wrote, “I think it’s very important to see the concepts that they are learning in action, such as applying math in everyday things like going shopping or balancing a checkbook,” and another

respondent stated, “Learning of any type should be fun. There should be real-world applications as well to make the child understand why they need to know it.”

### **Conceptual Knowledge for Helping my Child**

Items 8-13 (Appendix A) addressed participant perceptions of their understanding of conceptual strategies and the development of their children’s conceptual understanding of mathematics. Figure 2.2 shows that 49.2% of the survey participants strongly agreed, and 45.9% of parents agreed that they could use multiple tools to show the relationship between area and perimeter, for a total of 95.1%. Fifty-seven and four tenths percent of participants strongly agreed, and 37.7% of parents agreed (a total of 95.1%) with the statement that they could help their children use pictures and objects to model fractions. Fifty-seven and four-tenths percent of parents strongly agreed, and 37.7% of parents agreed that they could use different strategies to model the multiplication and division of whole numbers, for a total of 95.1%. Sixty-five and six-tenths percent disagreed, and 27.9% strongly disagreed that current mathematics instruction was similar to how they learned mathematics, for a total of 93.5%. Fifty and eight-tenths percent of parents strongly agreed, and 49.2% of parents agreed that they could help their children solve story problems, for a total of 100%. Overall, an average of 96.3% of survey participants stated that they believed they could develop their students’ conceptual understanding using various strategies, and 93.5% stated that standards-based instruction is very different from how they learned mathematics. There were no significant differences between responses, which were differentiated by the participants’ professions.

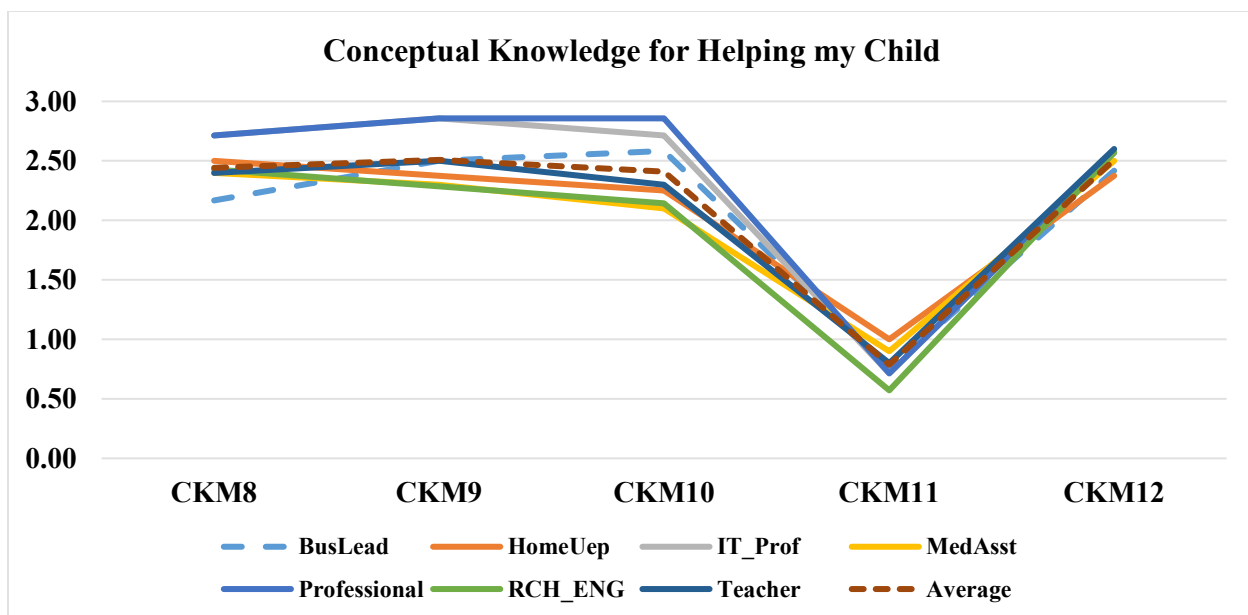


Figure 2.2. Conceptual Knowledge for Helping my Child graph

### Mathematics Knowledge for Helping my Child

Items 14-18 (Appendix A) addressed survey participants' perceptions of their abilities to use their mathematics understanding to help their children learn mathematics effectively. Figure 2.3 shows that 42.6 % of parents strongly agreed, and 42.6% of parents agreed that they could explain to their child how to multiply and divide decimals, for a total of 85.2%. Forty-five and nine tenths percent of parents strongly agreed, and 45.9% of parents agreed that they could explain to their child how to multiply fractions, for a total of 91.8%. Fifty-two and five tenths percent of parents strongly agreed, and 44.3% of parents agreed that they could teach their child how to multiply two-digit whole numbers. Therefore, 96.8% of parents, in total, stated that they could teach their children how to multiply two-digit whole numbers. Forty-seven and five tenths percent of parents strongly agreed, and 47.5% of parents agreed that they could explain the relationship between decimals and fractions, for a total of 95%. Forty-seven and five tenths percent of parents strongly agreed, and 47.5% of parents agreed that they could explain the connection between fractions and decimals for a total of 95%. In response to the survey

questions that asked parents to describe their backgrounds in mathematics, 68.8% of online respondents (N=42) stated that they took college-level mathematics courses. Overall, an average of 92.8% of the survey participants reported that they believed they could explain an assortment of mathematical skills to their children. The teachers and medical assistants scored below average and reported the lowest levels of mathematics knowledge for reinforcing instruction.

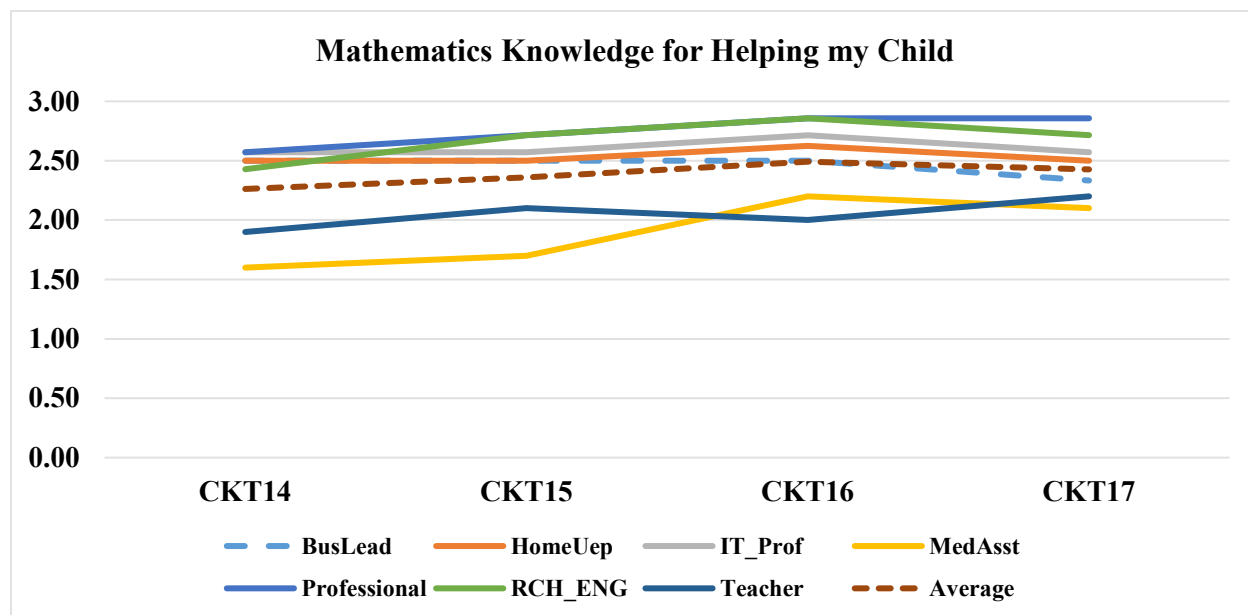


Figure 2.3. Mathematics Knowledge for Helping my Child graph

### Mathematics Self-Efficacy

The majority of online participants stated that they were confident in developing their child's mathematical abilities, as indicated by items 18-23 (Appendix A). Figure 2.4 shows that 83.6% of parents (strongly agreed: 41% and agreed: 42.6%) stated that they could help their children with all of their homework, and 50.9% of parents (strongly agreed: 23% and agreed: 27.9%) stated that mathematics was their favorite subject to teach. Sixty and seven tenths percent (strongly agreed: 14.8% and agreed: 45.9%) stated that they knew how to motivate their children. Sixty-seven and two tenths percent of parents (strongly agreed: 21.3% and agreed: 45.9%) stated that they were confident in their ability to explore mathematics with their child



using multiple strategies. An average of 65.6% of parents expressed confidence in their ability to help their children learn mathematics. Figure 2.4 illustrates the largest spread in responses from the mean. Scores decreased at item 20 (MSE20), which addressed whether mathematics was their favorite subject to work with their children on. Scores also fluctuated at item 21 (MSE21), which was about how confident participants felt motivating their child to learn mathematics. The researchers/engineers and professionals were the only professions whose scores stayed above the mean responses, and the medical assistants' and business leaders' responses stayed below the mean responses.

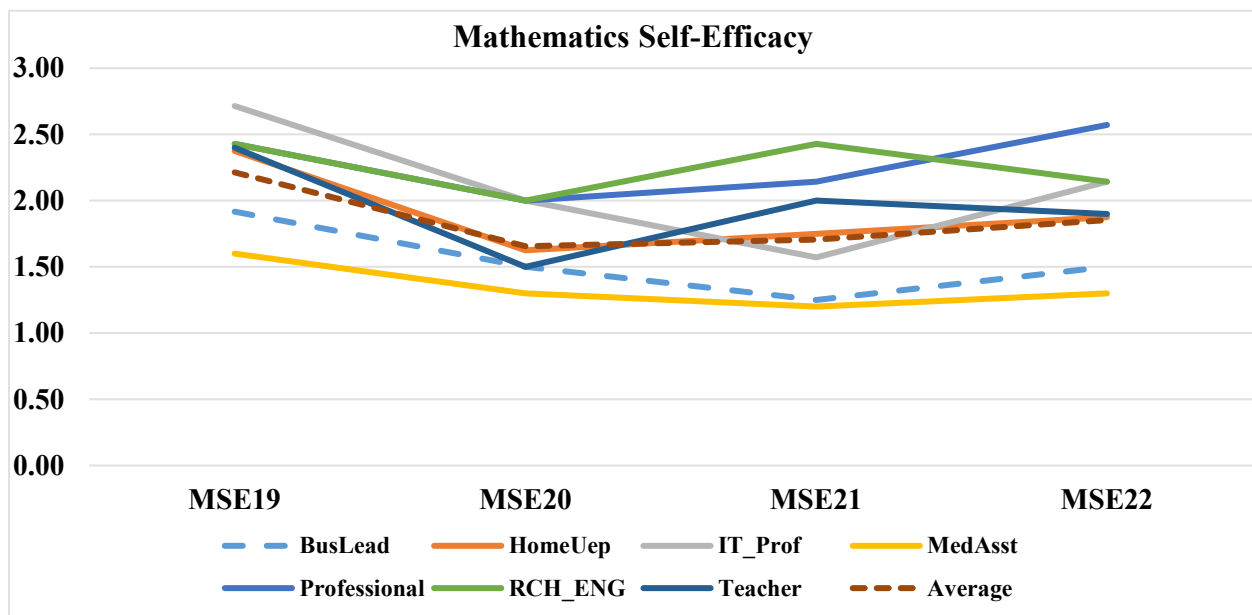


Figure 2.4. Mathematics Self-Efficacy graph

The themes that emerged when examining parent mathematics self-efficacy were *involvement* and *experience*. Parents who reported lower self-efficacy levels regarding current mathematics instruction noted how they were not provided with sufficient support to be effectively involved in their child's learning. Other participants expressed diffidence, which appeared to stem from their limited experience with current mathematics instruction.

A descriptive code that was identified was *additional assistance*, reflecting the theme of involvement. One respondent stated:

I think it is important to provide materials to the parents to help them learn the math as it is being taught to their children. I have struggled with assisting my child complete assignments in the way that they have been taught in school.

Another participant wrote, “Parents need mathematical support/training so that we can help our children.” A third participant noted:

I can help my child with many aspects of mathematics but it poses a great challenge when I cannot help them with the way they are being taught in school. It creates extra time for homework and frustration. I often have to look something up in order to re-learn it and then work with my child to help them find the answer with the new method.

Another participant explained:

It would be of great if the topics to be taught can be shared with the parents and also if the students can bring back home every day the work they did at school. The parents can go through the topics at home too so that students can discuss again and see if they understand what is being taught at school. The syllabus is available in HCPSS website for each quarter but again if parents can know what topic is being taught per week it would greatly useful to parents to help students at home.

One participant wrote, “There are lots of new and great strategies being taught at school. If they are shared with parents, we can reinforce the same at home too. As parents, we are not used to learning these new strategies.”

Several participant responses illustrated the descriptive code of *new strategies*, indicative of their limited collective experience with current mathematics instruction. One participant

stated, “It’s very different than when I was growing up. It’s even changed since I began teaching 16 years ago.” Another participant wrote, “I think it’s hard for parents to teach the new way y’all [sic] teach math because we weren’t taught it lol.”

### School-Home Communication and Support

Figure 2.5 shows that many survey respondents receive support from their child’s teacher in response to items 24-26 (Appendix A). The most common instructional supports were in the form of (a) links to informational websites about learning mathematics (N=46), (b) meaningful mathematics sheets and homework (N=45), (c) recommendations for apps, websites, and videos (N=39), and (d) toys or games about mathematics (N=34). The supports that participants reported receiving the least of were (a) books on math (N=4), (b) math songs (N=5), and (c) mathematics-themed children’s books (1). Only three of the 61 online participants reported not receiving support from their child’s teacher.

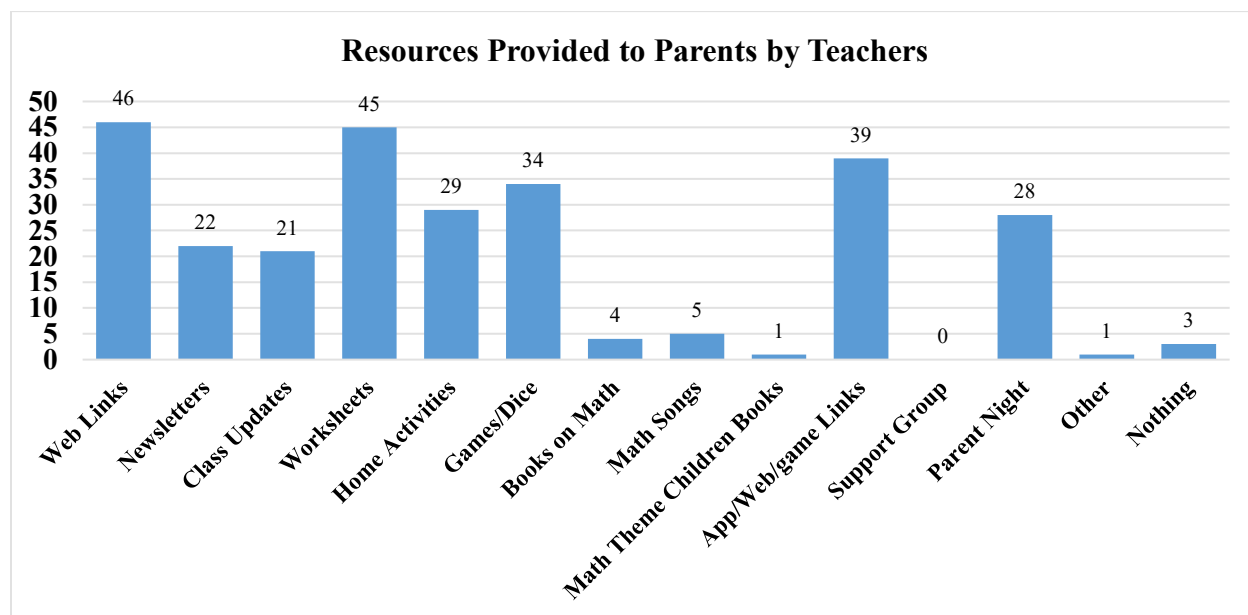


Figure 2.5. Resources Provided to Parents by Teachers graph

Regarding parental supports, the descriptive code, *written materials*, emerged representing the theme of *different supports*. Many participants wanted written materials that would help them assist their children with mathematics. One survey participant responded:

And sometimes I can explain to my child how to solve different problems but I am not sure if it is the way they were taught [taught] (often not) ...and here the confusion comes. Some methods are different so books, journals or parent recourses would be helpful for reference at home.

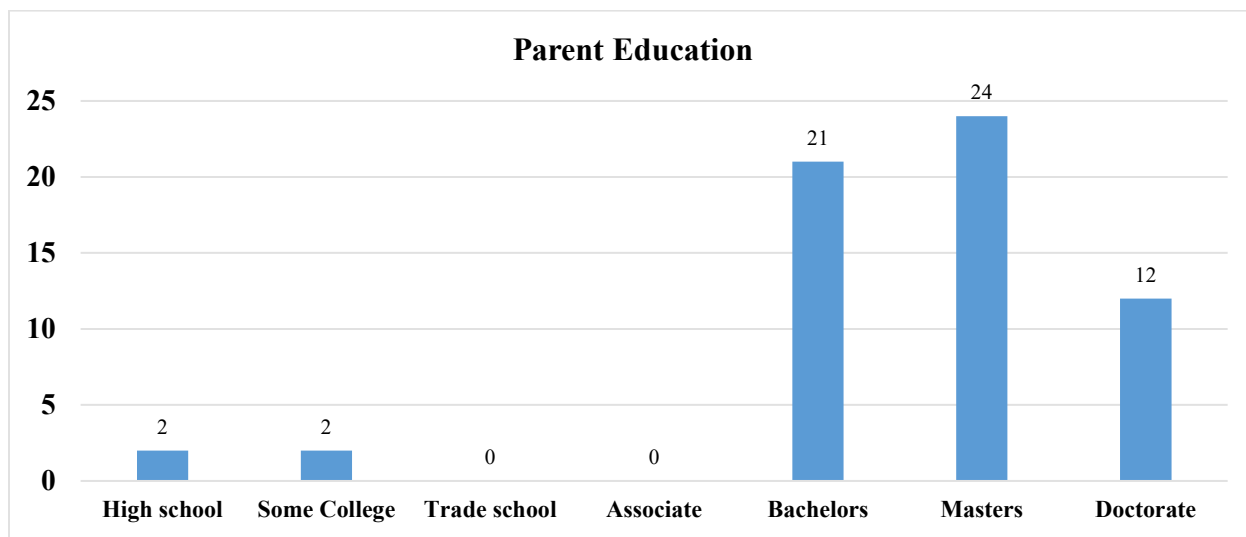
One interviewee discussed his desire for a textbook, “Like to have at least a book...then I can follow pretty much the chapters and the curriculum.”

Another interviewee expressed frustration in her failed attempts to retrieve a standards-based textbook from her child’s teacher:

We have tried multiple times to get a textbook from my son’s teacher, and I can tell that it does not address what my son is learning in school. It was old and outdated. Do teachers not have access to Common Core textbooks?

### **Parent Characteristics**

Survey items 27 and 28 addressed parent characteristics. Figure 2.6 shows the education levels of survey respondents. Twenty-one online respondents earned a bachelor’s degree, and 24 online participants earned a master’s degree. Twelve online participants earned a doctorate as their highest form of educational attainment. Two parents reported that high school was their highest level of schooling, and two parents reported having taken some college courses. In response to item 28, the following parent professions for online participants were reported: researchers/engineers (N=7), unemployed/homemakers (N=8), IT professionals (N=9), professionals (N=7), teachers (N=11), medical assistants (N=9), and business leaders (N=10).



*Figure 2.6. Parent Education graph*

## Findings

### Beliefs about Mathematics Learning

A high percentage of participants had positive beliefs about mathematic learning, contrary to existing literature about how many U.S. parents have negative mathematics beliefs (Ginsburg et al., 2008; Goldman & Booker, 2009; Remillard & Jackson, 2006). According to Ginsburg et al. (2008), many adults, who lack basic mathematics skills, experience frustration with standards-based strategies or mathematics in general. As a result, these adults are more inclined to avoid mathematics (Sloan, 2010; Stoechr, 2017). In contrast, the survey participants appeared to have a sufficient number of positive experiences, evidenced by the high percentage of parents who completed college-level mathematics courses and their willingness to engage their children in mathematics activities at home.

Their positive views are illustrated by approximately 100% of survey respondents, who discussed the importance of helping their children with mathematics, their children experiencing mathematics in everyday life, and the importance of their child liking mathematics. Additionally,

Figure 2.1 shows that less than half of parents believed that mathematics is more about memorization than understanding. This finding suggests that participants may be receptive to learning conceptual mathematics strategies, which emphasize the development of mathematical understanding over memorization.

### **Conceptual Knowledge for Helping my Child**

Over half of the participants demonstrated that they had sufficient knowledge of using multiple tools (e.g., pictorial representations, manipulatives) for developing conceptual knowledge, contradicting existing literature that examined parents' limited conceptual knowledge for helping their children (Goldman & Booker, 2009; Remillard & Jackson, 2006). Figure 2.2 indicates that less than half of participants responded that current mathematics instruction is similar to how they learned mathematics, aligning with current literature that examined how parents experience a significant mismatch between current and past mathematics instruction (Goldman & Booker, 2009; Jackson & Remilliard, 2005; Remillard & Jackson, 2006).

### **Mathematics Knowledge for Helping my Child**

The majority of survey participants reported high levels of mathematics knowledge for developing their children's mathematical abilities with over half stating that they could help their children compute fractions, decimals, and whole numbers. Furthermore, interviewees and survey participants expressed their ease with foundational mathematics and their comfort with creating new mathematics problems in addition to their children's homework.

These findings demonstrate a departure from existing literature about the many U.S. parents that lack basic mathematics skills and struggle to help their children as a result (Ginsburg et al., 2008). Although participants demonstrated mathematics competence, Figure 2.3 indicates

that some participants need assistance in developing their children's ability to calculate with fractions and decimals. A lower number of parents responded that they knew how to help their children multiply and divide decimals and fractions and explain the fraction and decimal relationship, compared to the number of parents who stated that they could teach multiplying and dividing two-digit whole numbers. Additionally, teachers and medical assistants scored below mean responses for items 14-17, suggesting that teachers and medical assistants may need additional mathematics assistance and may be unaware of the methods taught.

### **Mathematics Self-Efficacy**

The mathematics self-efficacy findings align with existing literature about how parents have reduced confidence in supporting their children's mathematics learning (Ginsburg et al., 2008; Goldman & Booker, 2009; Remillard & Jackson, 2006). Figure 2.4 demonstrates the largest variation in responses, concerning parents who indicated confidence in using multiple strategies to explore mathematics, in motivating their children to learn mathematics, and expressing mathematics as their favorite subject to teach their child. Additionally, medical assistants and business leaders scored the lowest in mathematics self-efficacy, suggesting that they may need additional support for improving their confidence.

An average of over 90% of survey respondents demonstrated positive mathematics beliefs and strong mathematical knowledge and conceptual knowledge for helping their children, but the averaged survey responses about mathematics self-efficacy (65.6%) were surprisingly low in comparison. Lower levels of mathematics self-efficacy may result from unfamiliarity with standards-based strategies as one online participant responded, "Memorization was the method I was taught versus teaching the different concepts to help you solve the problem."

Responses to questions were well aligned across the majority of constructs, but the greatest variation occurred for the mathematics self-efficacy items that addressed mathematics as the favorite subject to teach and confidence in motivating their child. The difference in responses about mathematics self-efficacy compared to parent beliefs, mathematical knowledge and conceptual knowledge for helping their children, suggests that the proposed intervention may need to address the largest declines in confidence, which were in motivating children to learn mathematics and mathematics as a favorite subject to teach.

### **Home-School Communication and Support**

As Figure 2.5 indicates, parents received varied resources from their children's teachers. The top four resources that parents referenced were web links, worksheets, apps/websites/game links, and games. Although the majority of parents received some form of school support, many online participants explained that they wanted more support in the form of instructional materials that developed their understanding of standards-based instruction for reinforcing mathematics instruction. In conjunction with overall low mathematics self-efficacy, these findings may indicate that teachers in the current setting are not effectively providing materials to meet parent needs.

### **Parent Characteristics**

The majority of parents in the survey reported high levels of educational attainment. Furthermore, approximately 60% of online participants used high-skilled mathematics in their professions. Thus, although approximately 70% of online participants took college-level mathematics courses, many did not frequently use high-skilled mathematics or mathematics in their careers, suggesting that a large portion of the parent population may need additional assistance in developing their mathematics skills.



## **Limitations**

Data was collected by emailing surveys and conducting in-person interviews. Some parents in the interviewing process had difficulty answering questions and were unable to elaborate on open-ended responses due to language barriers. The online respondents provided more information to the open-ended questions responses, appearing to have a better command of English. Additional limitations were that the survey did not collect data on gender, ethnicity, and SES, limiting the analysis of variables that may have influenced participant responses. The interviews were conducted by one researcher, whom the participants knew, which may have influenced responses. The survey sample size was also small (N=67), which likely impacted evidentiary validity.

## **Chapter Conclusion**

Although the majority of parents received school support and had strong mathematics backgrounds and instructional abilities, many wanted additional assistance. Their lower levels of mathematics self-efficacy may have resulted from limited access to instructional materials. For example, many participants wanted access to textbooks, a resource that only four online participants and zero interviewees reported receiving. Although 45 out of 61 online participants stated that their children received meaningful homework, many participants wanted teachers to assign more homework. Four out of six interviewees also indicated a desire for more homework. Many respondents expressed how teachers should improve homework, as encapsulated by this response, “I wish the homework had examples. That would help us parents understand and help our kids.” Thus, parent requests for more homework and more resources suggests that their limited access to materials may have influenced their mathematics self-efficacy levels.

A few participants expressed that they did not receive adequate school resources, resulting in participant frustration and misunderstandings about standards-based strategies. While

conceptual strategies focus on teaching multiple ways to approach problems, many participants preferred one process for solving as encapsulated by the parent response, “Problems are dissected/broken out more and take much longer to solve.” The creators of CCSSM promoted instruction that develops critical thinking skills by using many strategies and tools for problem solving (CCSSO & NGA, 2019). Thus, instruction emphasizes helping students to evaluate the best strategies to use for specific problems given their knowledge of multiple strategies for problem solving. A few parents also noted that standards-based instruction did not address relevant activities (e.g., calculating percentages, paying bills), but these topics are addressed explicitly in the sixth and seventh grade standards (CCSSO & NGA, 2019). Greater access to school materials and resources that explicitly state mathematics concepts and the advantages of standards-based strategies could mitigate parent misunderstandings and frustrations.

Parent participants reported strengths in the constructs conceptual knowledge for helping my child and mathematics knowledge for helping my child. Although some participants reported difficulty understanding the way mathematics is taught, the majority of parents did not. Moreover, results for parents regarding beliefs about mathematics learning, conceptual knowledge for helping my child, and mathematics knowledge for helping were largely aligned, but results for mathematics self-efficacy differed greatly among parent professions. Medical assistants and business leaders reported self-efficacy levels that stayed below average compared to other professions that reported average or above-average levels of self-efficacy. These significant results may indicate that medical assistants and business leaders need additional support during the proposed intervention.

Responses about the items that addressed conceptual knowledge for helping my child were tightly grouped and exceptionally high, contradicting existing literature about how parents

have a weak understanding of conceptual mathematics strategies (Goldman & Booker, 2009; Jay et al., 2018; Marshall & Swan, 2010; Remillard & Jackson, 2006). Figure 2.2 shows a decline at item 11 (CKM11), which addressed how similarly students learned mathematics compared to how they learned mathematics, aligning with the literature that parents recognize major differences in how they and their children learned (Goldman & Booker, 2009; Jay et al., 2018; Marshall & Swan, 2010; Remillard & Jackson, 2006).

As Figure 2.1 indicates, a sharp decrease occurred at items four (BLM4) and five (BLM5R). Item four addressed mathematics instruction as being more effective than how parents were taught. These results may indicate that parents believe that current strategies are not as effective or may misunderstand the strategies. Some parent responses suggest that limited access to school materials led to their frustration and misconceptions about current mathematics instruction. Parent responses to item five about how mathematics was more about memorization than understanding suggest that parents are more amenable to learning additional strategies that create a deeper understanding of mathematics that may not be completely dependent upon memorization. Thus, in regards to items four and five, parents appear to want their children to learn efficient strategies that also deepen their child's understanding of mathematics.

The major discrepancies in parent responses were about mathematics self-efficacy. Results revealed participants' lower levels of mathematics self-efficacy, suggesting that their strong mathematics backgrounds, instructional abilities, and positive beliefs about current instruction may need additional support. Therefore, the intervention will seek to provide effective school supports that meet help parents develop a better understanding of standards-based mathematics and improve their mathematics self-efficacy.

## **Chapter Three**

### **Providing Mathematics Support**

Many parents, defined as the primary caregivers (Williams & Williams, 2019), or adults who are principally responsible for extending the child's learning and reinforcement of school instruction (Mangram & Metz, 2018), encounter difficulties engaging their children in mathematics learning, stemming from their unfamiliarity with current mathematics instruction. In the needs assessment study, parent participants of upper-elementary students noted substantial differences between current mathematics instruction and how they learned mathematics. Limited access to instructional materials also contributed to their unfamiliarity with current instruction. Parents can have a significant positive impact on student mathematics development, but barriers such as unfamiliarity with school mathematics and inadequate access to resources limit the quality of their involvement (Jackson & Remilliard, 2005; Jay et al., 2018; Remillard & Jackson, 2006). To address this phenomenon, an intervention will be developed that focuses on providing parents with instructional materials and resources to cultivate their mathematics knowledge for teaching to better support their children's learning.

Participants also scored the lowest on mathematics self-efficacy out of other needs assessment constructs (e.g., beliefs about mathematics learning, conceptual knowledge for helping my child, mathematics knowledge for helping my child, mathematics self-efficacy, school-home communication and support), which could interfere with their mathematics engagement with their children. U.S. parents experience lower levels of mathematics self-efficacy due to their unfamiliarity with mathematics content and instruction (Jackson & Remilliard, 2005; Jay et al., 2018; Remillard & Jackson, 2006). Mathematics self-efficacy is generally predictive of mathematics achievement and mathematics-related behavior (Jameson & Fusco, 2014). Those with higher levels of self-efficacy are more likely to take on challenges and

increase their efforts to meet their objectives (Schunk & Ertmer, 2000; Williams & Williams, 2010). Therefore, this literature overview was focused on parent mathematics self-efficacy by examining interventions that empowered them to overcome challenges that they faced in helping their children with mathematics learning. An objective of this examination was to better understand parent mathematics self-efficacy to create an intervention program that improved their support of their children's mathematics learning.

In summary, in alignment with the scholarly literature, needs assessment results suggest that parents' primary obstacles to providing sufficient mathematics support are limitations in their mathematics knowledge for teaching and mathematics self-efficacy. Therefore, effective interventions should prioritize the development of mathematics knowledge for teaching because low levels of parent mathematics knowledge negatively impact parent mathematics self-efficacy (Jay et al., 2018; Marshall & Swan, 2010; McMullen & de Abreu, 2011; Mistretta, 2013; Remillard & Jackson, 2006). The following section contains an introduction about the potential of parents serving as mathematics resources for their children.

### **Intervention Literature Review**

High parent involvement is generally associated with high student achievement (Cheung & Pomerantz, 2011; Griffith, 1996; Jeynes, 2007). However, studies about their involvement in mathematics have yielded inconsistent findings. For example, parent engagement sometimes produced positive results on student mathematical abilities (Kleemans, Peeters, Segers, & Verhoeven, 2012; LeFevre et al., 2009; LeFevre, Polyzoi, Skwarchuk, Fast, & Sowinski, 2010), while in other studies, parent involvement yielded negligible to negative effects on student mathematical abilities (Blevins-Khabe, Austin, Musun, Eddy, & Jones, 2000; Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015). These findings suggest parent engagement does not

automatically equate to improvements in student mathematics development.

Specific types of parent activities appear to have different effects on student mathematics achievement. Activities that generate rich mathematical discussions correlate with higher mathematics knowledge in pre-elementary school-aged children (Levine, Suriyakham, Rowe, Huttenlocher, Gunderson, 2010; Pruden, Levine, & Huttenlocher, 2011). However, mathematics discussions between pre-school children and parents involving concrete items that number less than four, do not correlate with an increase in mathematics ability (Gunderson & Levine, 2011a). Furthermore, engagement in *formal home learning activities* (parent instruction for the express purpose of developing student mathematic skills) and *informal home learning activities* (parent instruction that indirectly involves mathematics tasks) predict specific student achievement in the first grade (Skwarchuk, Sowinski, & LeFevre, 2014; Yildiz, Sasanguie, Smedt, & Reynvoet, 2018). Specifically, informal numeracy activities (e.g., puzzles, cooking) are associated with kindergarteners' abilities to manipulate number quantities, and formal home numeracy activities (e.g., counting games, number games) can predict their arithmetic abilities. These studies were intentionally included to highlight the promising potential parents have in developing their children's mathematics skills before their children have received years of formalized instruction. These effects could be greater if parents were provided with appropriate information and resources to support their children's mathematics learning. Thus, the next section contains an explanation of Ball, Thames, and Phelps' (2008) mathematics knowledge for teaching framework (MKT), which served as a lens for examining interventions that improved parent mathematics support through improving their mathematics instructional knowledge.

### **Theoretical Framework: Mathematics Knowledge for Teaching**

Ball and colleagues (2008) developed the MKT framework (Table 3.1) to explain what educators need to know and what skills they require to teach their students effectively. This framework consists of six components. Common content knowledge (CCK), specialized content knowledge (SCK), and horizon content knowledge (HCK) all fall under subject matter knowledge. Knowledge of content and students (KCS), knowledge of content and curriculum, and knowledge of content and teaching (KCT) fall under pedagogical content knowledge. All components were described in chapter one, but chapter three focuses exclusively on Ball et al.'s (2008) KCT. KCT, an understanding of mathematics concepts and teaching methods, is a blend of two constructs (knowledge of teaching and knowledge of content) associated with high-quality elementary school instruction (Thames & Ball, 2010). The development of KCT was examined in interventions that helped parents more effectively participate in their child's mathematics learning.

Ball and colleagues (2008) conceptualize teaching unique to educators using the MKT framework, so parent mathematics knowledge for teaching represents a moderated version of KCT. The intervention's aim was to identify ways to help parents better support their children. The intervention was not intended to elevate parents' mathematics knowledge to that of a teacher's instructional levels, but to provide sufficient background so that they are able to reinforce school instruction. Needs assessment results also indicated that lower levels of mathematics knowledge for teaching affect parent confidence and mathematics self-efficacy with helping their children. For example, the parent who considered himself or herself the least competent in mathematics was the parent who participated the least in their child's mathematics learning. The next sections contain an explanation of how Bandura's (1986) triadic reciprocal determinism theory with his self-efficacy theory informed the review of intervention literature

that addressed how to improve parent mathematics support by improving their mathematics knowledge for teaching and mathematics self-efficacy.

Table 3.1

*Mathematics Knowledge for Teaching*

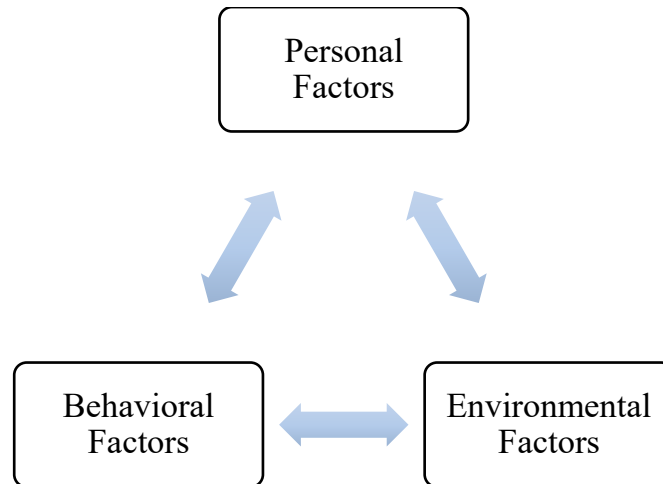
Subject Matter Knowledge	Pedagogical Knowledge
Common Content Knowledge (CCK)	Knowledge of content and students (KCS)
Horizon Content Knowledge (HCK)	Knowledge of content and teaching (KCT)
Specialized content knowledge (SCK)	Knowledge of content and curriculum (KCC)

Adapted from ‘Content knowledge for teaching: What makes it special?’  
by D.L. Ball, M.H. Thames, and G. Phelps, 2008, Journal of Teacher Education, 59(5), p. 403.

### **Theoretical Framework: Social Cognitive Theory**

Bandura’s (1986) social cognitive theory posits that learning occurs in social settings, and two subsets of the social cognitive theory, triadic reciprocal determinism theory and self-efficacy theory were examined. Bandura (1986) used the triadic reciprocal determinism framework (Figure 3.1) to explain how three factors, behavioral, environmental, and personal, continually reinforce each other and influence life outcomes. Self-efficacy, a personal factor incorporated in the triadic reciprocal determinism framework, is what Bandura (1986) defined as the beliefs that people have regarding their skills. Self-efficacy, impacted by one’s interactions with the environment, influences one’s behaviors, and environmental stimuli respond to the individual’s behaviors, which are influenced by one’s thoughts regarding their ability (Bandura, 1986).





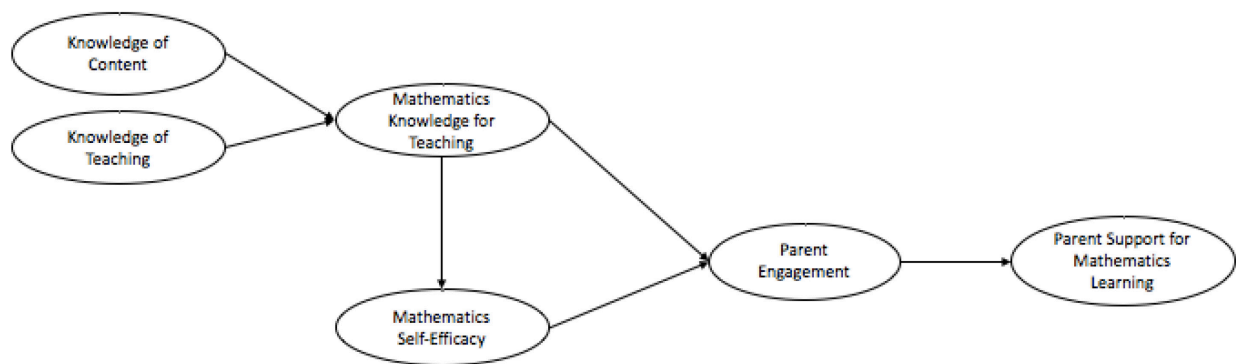
*Figure 3.1.* Triadic Reciprocal Determinism Theory (Bandura, 1986)

Many adults have a lifetime of negative mathematics learning experiences, environmental factors (Sloan, 2010; Uusimaki & Nason, 2004), particularly U.S. adults, who have low mathematics self-efficacy, personal factors, as a result (U.S. Department of Education, 2015, as cited in Safford-Ramus, Misra, & Maguire, 2016). On account of personal factors and environmental factors, parents may express their negative attitudes, anxieties, and beliefs to their child, reducing their child's mathematics achievement (Maloney et al., 2015). In the context of the needs assessment, parent participants expressed how their level of mathematics involvement depended on their perceived abilities in helping their child, findings that are consistent with existing literature (O'Sullivan, Chen, & Marian, 2014). Participant responses on the needs assessment revealed that their self-efficacy levels were linked to their knowledge of standards-based mathematics. Furthermore, high parent mathematics confidence correlates with the quality of mathematics support they provide (Hyde, Else-Quest, Alibali, Knuth, & Romberg, 2006). Therefore, Bandura's (1986) triadic reciprocal determinism theory with the inclusion of his self-efficacy theory was appropriate for guiding an examination of intervention literature that demonstrated how establishing situational elements (environmental factors) that promote

mathematics knowledge for teaching and mathematics self-efficacy (personal factors) improve parent mathematics engagement (behavioral factors).

### **Conceptual Framework**

This literature review is grounded in an understanding of Ball et al.'s (2008) MKT framework and Bandura's (1986) triadic reciprocal determinism theory with his self-efficacy theory in an examination of cognitive and non-cognitive variables that improve parent mathematics support. A conceptual framework (Figure 3.2) contains parent mathematics knowledge for teaching, which consists of knowledge of content and knowledge of teaching, which combined, form KCT, a construct of the MKT framework. The connecting lines in Figure 3.2 illustrate how parent mathematics knowledge for teaching influences parent mathematics self-efficacy and their engagement, which influences their ability to support their child learning mathematics. Parent mathematics self-efficacy also influences parent engagement and how they support their child's learning. Interventions that promote conditions (environmental factors) that increase parent mathematics knowledge for teaching and mathematics self-efficacy (personal factors) may improve parent engagement, and thus support (behavioral factors) for their child's mathematics learning. Therefore, Bandura's (1986) triadic reciprocal determinism model and self-efficacy theory and Ball et al.'s (2008) KCT guided the intervention that addressed the interrelated personal, environmental, and behavioral factors that impacted parent mathematics engagement and their child mathematics learning.



*Figure 3.2. Conceptual Framework of Cognitive and Non-Cognitive Factors*

## Literature Review

In the next sections, interventions were examined that improved parent mathematics knowledge for teaching using collaborative learning, mathematics tasks for problem solving, and direct guidance on mathematics instruction. Interventions that improved parent mathematics self-efficacy by providing self-guided tools and emotional support were also explored. After examining 20 programs that addressed these objectives, the researcher proposed an intervention that reflected components that effectively improved parent mathematics knowledge for teaching and parent mathematics self-efficacy.

### Interventions Addressing Mathematics Knowledge for Teaching

According to Knowles (1984), adult learners accumulate many experiences that they can draw upon for learning. Specifically, parents have mathematics experiences accrued over a lifetime and engage in complex mathematical practices in everyday life (Goldman & Booker, 2009; Jackson & Remilliard, 2005; Remilliard & Jackson, 2006). Unfortunately, many parents are unfamiliar with current mathematics instruction and have been unable to capitalize on their own experiences to provide mathematics learning opportunities at home (Goldman & Booker, 2009; Remillard & Jackson, 2006). Furthermore, many adults have had negative experiences with mathematics (Sloan, 2010; Uusimaki & Nason, 2004). Moreover, many parents have an

extensive view of mathematics in their daily lives and simultaneously have a narrower view of mathematics concerning school learning (Goldman & Booker, 2009; Jackson & Remillard, 2005). Thus, effective interventions for improving mathematics knowledge for teaching help parents connect everyday life to school instruction and incorporate what they learned into their mathematics activities with their child. The next sections demonstrated how interventions improved parent mathematics knowledge for teaching through collaborative learning, mathematics tasks for problem solving, and direct guidance on knowledge of content and teaching (KCT).

### **Collaborative Learning**

Collaborative learning is the process of people working together to solve a problem or complete a task (Vygotsky, 1978), and it often involves learners who are responsible for their own and each other's learning (Laal & Ghodsi, 2011). Academic benefits associated with this method include enhanced critical thinking skills and increased engagement and motivation (Laal & Ghodsi, 2011). Collaborative learning is particularly effective in reinforcing student learning and ability when more capable adults or peers guide less capable students, capitalizing on others' different strengths and ideas (Vygotsky, 1978). Thus, developing an in-depth understanding of mathematics can occur when people are actively processing mathematics from the experiences they share with others (Boaler, 1998; Mangram & Metz, 2018). After examining 20 interventions, additional information is located in Appendix B, the researcher determined that collaborative learning was found in every intervention, indicating its importance in improving parent mathematics knowledge for teaching. Papadopoulos (2017) and Mangram and Metz (2018) demonstrated how to use collaborative learning differently to address the knowledge of

content component of the parent mathematics knowledge for teaching construct from the conceptual framework (Figure 3.2).

In one workshop session (duration not provided) of 24 parents of children aged 10 and 11 from the same class, Papadopoulos (2017) focused primarily on improving teacher-parent partnerships through collaboration, resulting in a secondary outcome of improved parent mathematics knowledge. The session consisted of two stages: arithmagons and times-plus houses (Appendix C; Appendix D). Arithmagons (Appendix C) are number puzzles where each box with a number outside of the triangle is the sum of two adjacent kites that contain their own numbers (Papadopoulos, 2017). Papadopoulos (2017) used the first stage to familiarize parents with arithmagons. Parents worked together to solve the tasks while the teacher guided and monitored their progress. Groups presented how they arrived at solutions and defended their answers. In the second stage, parents collaborated on creating activities that involved the use of times-plus houses for their children. The researcher recorded and transcribed this session and found that collaboration among adults led to improved mathematics knowledge for teaching. Using Blooms' taxonomy, Krathwohl (2002) noted that students demonstrated the highest form of learning when they create something new that demonstrates their thinking, and these participants demonstrated the highest form of learning when they co-created a series of instructional ideas for the use of times-plus tables. Thus, developing their knowledge of mathematics content in the process.

While Papadopoulos' (2017) primary objective was to increase parent and teacher collaborations, Mangram and Metz's (2018) main goal was to develop parent mathematics knowledge. Mangram and Metz's (2018) program consisted of five workshop sessions in which three parent participants collaborated with their middle school students. Each session lasted

approximately two hours, and facilitators guided parent-child interactions as they participated in mathematics activities (e.g., playing games, error analysis), reviewed information from previous sessions, and learned new information that developed their understanding of the eight Common Core State Standards for Mathematical Practices (CCSS-MP).

Mangram and Metz (2018) used pre-and post-tests to measure the number of *talk turns*, which occurred when participants initiated discussions during problem solving. In addition to measuring who initiated the talk turns between parent-child dyads, they also examined on which CCSS-MP the participants made the most improvement. Through video recording and transcribing, Mangram and Metz (2018) found that parent-child partnerships engaged in more talk turns in the post-test. After the intervention, the average number of times parents initiated talk turns increased from 90 to 199, and parents on average talked longer from 10:49 to 24:31 minutes (Mangram & Metz, 2018, p. 289). Parent-child discussions concerning MP1, “making sense of problems and persevere in solving them,” and MP3, “constructing viable arguments and critique the reasoning of others,” made the largest increase after the sessions (Mangram & Metz, 2018, p. 288). The increase in the number of parent-to-child talks turns, the duration of these discussions, and how parents improved in constructing arguments and assessing mathematical reasoning suggest that collaborative learning played a role in improving their knowledge of mathematics content.

Despite their small sample sizes, Papadopoulos (2017) and Mangram and Metz (2018) demonstrated how collaborative learning opportunities improve knowledge of content, a component of parent mathematics knowledge for teaching, as parent participants co-created lessons and worked with their children and researchers on tasks that facilitated discussion and problem solving. Their findings also align with Knapp, Landers, Liang, and Jefferson’s (2017)

and Mistretta's (2013) findings, where they developed parent mathematics knowledge of content by facilitating parent-child collaborations on problem-solving activities. Collaborative learning has been shown to increase the knowledge of content component of parent mathematics knowledge for teaching. Thus, to appeal to the current parent population that is highly engaged in their children's mathematics, opportunities for collaborative learning will be included in the intervention.

### **Mathematics Tasks for Problem Solving**

Mathematics tasks are problems designed to develop student thinking on mathematics concepts and include a broad range of activities that students engage in, such as questions, problems, and exercises (Doyle, 1983, 1988; Henningsen & Stein, 1997; Stein, Grover, & Henningsen, 1996). Some tasks can be one problem or a series of problems that require students to attend to or address specific mathematical concepts (Stein et al., 1996). Specifically, mathematics tasks can require students to produce items (e.g., answers on a worksheet, respond orally in class), engage in procedures (e.g., using algorithms, selecting answers), and use resources (e.g., peer discussion, textbooks) to complete activities (Doyle, 1983, 1988). Authentic tasks are "coherent, meaningful, and purposeful activities" (Brown, Collins, & Duguid, 1989, p. 34) and based on real-world scenarios that transform mathematics concepts from abstraction to opportunities for "students to think and reason in complex ways" (Stein et al., 1996, p. 471). Thus, rich and authentic mathematics tasks can extend student knowledge to other contexts and expand their problem-solving capabilities in the process (Stein et al., 1996). Eighteen of the 20 interventions (Appendix B) examined involved mathematics tasks. Mistretta (2013) and Williams and Williams (2019) demonstrated how to use these activities to develop knowledge of

teaching, a component of the parent mathematics knowledge for teaching construct from the conceptual framework (Figure 3.2).

Mistretta's (2013) mixed methods study involved a graduate mathematics methods course and 18 pre-service teachers. The pre-service teachers conducted four monthly sessions using hands-on mathematics tasks with 30 parent-child dyads, and each session lasted approximately two hours. Each pre-service teacher was assigned to work with one to two families, and each week, the methods instructor guided the pre-service teachers on the same mathematics tasks they would engage in with participants. For each session, the pre-service teachers guided parents through the collaborative tasks, observed and took field notes, and interviewed them. The pre-service teachers were required to write two blog posts about their experiences working with the participants, and the researcher quantified these posts by averaging the number of pre-service teachers who had similar observations. The postings indicated that 83% of the pre-service teachers observed that parent participants valued the mathematics tasks because they made it easier for them to converse with their child since they had multiple answers and ways to solve them. From an analysis of the blog posts, 78% percent of pre-service teachers reported that parents valued using manipulatives during the tasks to deepen their child's learning, and 61% reported observing how students were better able to explain their answers when the parents employed the guiding questions that the pre-service teachers taught them. These responses suggest that mathematics tasks played a role in developing parent knowledge of teaching in facilitating mathematics dialogue between parent-child dyads and helping parents learn how to use manipulatives and questioning techniques to develop student understanding of mathematics concepts.



Mistretta's (2013) study demonstrated how preservice teachers, serving as subject experts, can use mathematics tasks for problem solving to increase parent knowledge of teaching. In contrast, Williams and Williams' (2019) study demonstrated how students, serving as the primary subject experts, used interactive homework assignments to improve their parents' knowledge of teaching. Williams and Williams' (2019) study involved distributing packs to students (N=389), aged six to 11, containing mathematics tasks based on real-life scenarios every week for 20 weeks. In addition to tasks, each pack contained information for parents about homework objectives, mathematics objectives, lists of required materials, and a parent feedback form. Researchers also kept parent participants informed by inviting them to attend sessions to observe students discussing their strategies for solving with their teacher and peers. Under the guidance of their teacher and peers, students grew more capable of guiding their family members at home, which further reinforced their parents' understanding of current mathematics instruction. Students served as instructional resources for their parents, who in turn, were better able to extend their child's mathematics learning outside of the classroom.

After the intervention, researchers administered student questionnaires to assess student enjoyment of the homework assignments, conducted focus groups for parents, and interviewed the teachers. Researchers transcribed and coded the focus groups' responses, parent feedback sheets, student questionnaires, and teacher interviews. Parent participants noted how they began to incorporate mathematics discussions and activities with their children into their everyday lives, demonstrating how the mathematics tasks and the homework sessions improved their instructional knowledge. Furthermore, the researchers observed that participants were more motivated to engage in the mathematics tasks because they contained open-ended questions based on realistic problem-solving scenarios. Williams and Williams (2019) demonstrated that

mathematics tasks for problem solving helped develop parent knowledge of teaching through (a) student modeling of computational strategies, (b) exposing parents to essential mathematics content, and (c) helping parents recognize the mathematics they use in their everyday lives.

Williams and Williams' (2019) was a qualitative study that did not involve comparison groups, like the other interactive homework interventions (Balli, Demo, & Wedman, 1998; Loehr, Rittle-Johnson, & Rajendran, 2014; Lore, Wang, & Buckley, 2016; Van Voorhis, 2011a, 2011b). Despite these limitations, Williams and Williams (2011) is the only interactive homework program of the interventions examined in this paper that directly measured improvement in parent mathematics knowledge, as other homework interventions focused on increasing student mathematics achievement (Balli et al., 1998; Loehr et al., 2014; Lore et al., 2016; Van Voorhis, 2011a, 2011b). Moreover, Williams and Williams (2011) was also the only interactive homework study that (a) examined the quality of interactions between families, (b) guided student thinking on problem-solving strategies, and (c) invited parents to view student problem-solving strategies before they received the mathematics tasks. Williams and Williams (2011) also made the homework assignments easily accessible to parents online; a factor that is important for at-home interventions where parents do not have immediate access to the teacher or researcher.

Mistretta (2013) and Williams and Williams (2019) used mathematics tasks for problem solving differently to develop parent knowledge of teaching, a component of mathematics knowledge for teaching. Although Mistretta (2013) and Williams and Williams (2019) conducted non-experimental studies with self-selected samples, they triangulated multiple types of data (e.g., observations, interviews, focus groups, feedback forms, student questionnaires) to increase the credibility of their findings. These studies demonstrated the versatility of mathematics tasks

for problem solving for improving parent knowledge of teaching, with or without immediate teacher and researcher support. Additionally, Mistretta (2013) and Williams and Williams (2019) demonstrated how tools, word problems based on realistic scenarios, and collaborative learning are effective elements for improving parent knowledge of teaching. These studies also illustrated the feasibility of incorporating these elements into an intervention.

### **Direct Guidance on KCT**

Modeling instructional skills and the use of tools for students are examples of direct guidance, which supports the development of both components of parent mathematics knowledge for teaching, knowledge of content and knowledge of teaching. These elements form KCT, a construct of Ball et al.'s (2008) MKT framework. A person with sufficient KCT understands specific models (e.g., base-ten blocks, unifix cubes, tape measures), examples, and skills and how to use them effectively to develop student understanding (Ball et al., 2008). Because KCT is a form of specialized knowledge that educators typically employ (Ball et al., 2008), teachers, who have received formalized training, are best suited for helping non-teachers develop this kind of instructional knowledge. Therefore, parents need direct guidance from teachers to develop a moderated form of KCT to reinforce mathematics instruction more effectively. Panaoura (2017) and Westenskow et al. (2015) demonstrated how direct guidance from teachers on employing an assortment of skills and tools enhanced both components of the parent mathematics knowledge for teaching construct.

Panaoura's (2017) study involved 117 fifth-grade students and 117 parents in four online workshop sessions, where she examined the relationship between parent views on school and homework involvement, student self-regulation, and student problem-solving performances, resulting in a secondary outcome of parents learning questioning techniques that enhanced their

mathematics knowledge of helping their children. Without indicating how far apart each session was in time, Panaoura (2017) used Adobe-Connect, a web conference tool, to conduct online sessions that were approximately an hour in length each. The first and second meetings were about the objective of mathematics instruction, the role of word problems and problem solving, and the challenges that students encounter during problem solving. The third and fourth meetings focused on how parents could use questioning and suggestions to improve their children's self-regulation and overall problem-solving capabilities. The researcher administered a questionnaire to assess parent views on their roles in homework and student regulation. She also administered a mathematics assessment to students containing rigorous word problems to assess student progress. The study's secondary outcomes were that instructing parents on how to use questions and redirect student thinking developed student self-regulation, improved student problem-solving abilities, and helped parents better understand their roles in helping their children learn.

While Panaoura (2017) used online sessions to show parents how to use questioning to improve student mathematics achievement, Westenskow et al. (2015) permitted parents to observe teachers working one-on-one with their children using a variety of methods and strategies to change their mathematics attitudes and improve how they engage their children in mathematics. Under laboratory conditions and through a window, parents observed seven to eight one-hour tutoring sessions and listened to student-teacher discussions wearing headphones. Although Westenskow et al. (2015) had a much smaller sample size (25 rising fifth-grade students and 24 parents) than Panaoura (2017), their study lasted ten weeks, and involved teachers who all had PhDs, more than 25 years of experience teaching, and experience researching struggling mathematics students.

Westenskow et al. (2015) administered surveys that contained open-ended questions to assess parent beliefs after the intervention and conducted phone interviews two weeks after the intervention with four parents to clarify survey responses. After coding participant responses, researchers found that parents noted how they changed how they engaged their children in mathematics after observing how these methods and practices improved student ability. Parents stated that they started to use computers (16%), participate in mathematics discussions (18%), and play mathematics games (15%). Half of the participants stated that they used pictorial representations and manipulatives as a result of their observations. Fifty-two percent of parents stated how they learned how effective pictures and manipulatives were in their child's learning, and 39% of parents discussed the importance of using multiples strategies for approaching problems (Westenskow et al., 2015).

Panaoura (2017) and Westenshow et al. (2015) are two very different intervention studies, highlighting the effectiveness of key features that warrant inclusion in the proposed intervention. Panaoura (2017) and Westenshow et al. (2015) demonstrated how direct guidance on instructional skills (e.g., questioning, discussion) and tools (e.g., pictorial representations, manipulatives, games) improved parent KCT or knowledge of content and teaching as they learned how to use a variety of techniques and tools to support student mathematics learning. These studies' findings align with other in-person interventions that also improved parent instructional skills by providing direct guidance on how to conduct mathematics discussions by using games (Mangram & Metz, 2018; Zippert, Daubert, Scalise, Noreen, & Ramani, 2019).

Effective interventions directed toward the home environment can also enhance parent KCT with weekly packets of interactive and educational activities that contain direct instructions for evaluating their children's learning (Muir, 2012). Packets with clearly-written instructions

and teacher directions on using manipulatives and instructional methods for their children's homework assignments can also improve parent KCT (Lore et al., 2016). Thus, direct guidance effectively develops the two components of mathematics knowledge for teaching (knowledge of content and knowledge of teaching) for in-person and at-home interventions. Direct guidance on instructional methods was included in the intervention using a series of questions that guided parent-child discussions and visuals that diagrammed how the conceptual mathematics strategies functioned. These examples of direct guidance are suitable for the current parent population, which is highly involved in their children's learning.

In referencing, Ball et al.'s (2008) MKT framework, specifically KCT and Bandura's (1986) triadic reciprocal determinism framework, establishing contexts (environmental factors) that include collaborative learning, mathematics tasks, and direct guidance on KCT can improve the parental iteration of KCT. Improvements in KCT (personal factors) influenced parent mathematics engagement (behavioral factors). The next sections highlighted intervention components that improved parent mathematics self-efficacy and mathematics engagement to support student learning.

### **Interventions Addressing Mathematics Self-Efficacy**

Mathematics interventions examined in this section focused on improving parent mathematics self-efficacy and their general mathematics orientations or mathematics dispositions. Bandura's (1986) social cognitive theory, specifically the triadic reciprocal determinism theory and the self-efficacy theory, demonstrate how individual beliefs are highly related to their behavior and environment, which collectively reinforce their beliefs. Thus, the combination of these theories guided the examination of the interventions that addressed mathematics self-efficacy.

Needs assessment results revealed that participants generally had positive mathematics orientations, specifically, positive mathematics beliefs and attitudes. These results reflected a departure from the literature (Ginsburg et al., 2008; Jackson & Remillard, 2005; McMullen & De Abreu, 2011). However, these results also showed how participants had lower levels of mathematics self-efficacy compared to their overall mathematics orientations. Needs assessment results revealed the challenges participants experienced with limited access to mathematics resources and discrepancies in how they learned mathematics and current school instruction. Therefore, of the sixteen intervention studies (Appendix B) that addressed parent mathematics orientation and mathematics self-efficacy, Berkowitz et al. (2015) and Schaeffer et al. (2018) were showcased for their use of self-guiding tools for improving mathematics self-efficacy. Additionally, Husain, Jabin, Haywood, Kasim, and Paylor (2016) and Jay et al. (2017) were examined for how they provided parents with emotional support that improved their mathematics self-efficacy.

### **Using Self-Guided Tools**

Many adults have negative mathematics feelings, stemming from negative experiences with mathematics in school (Uusimaki & Nason, 2004), particularly from the United States, who suffer from mathematics anxiety and an overall negative mathematics orientation (U.S. Department of Education, 2015, as cited in Safford-Ramus, Misra, & Maguire, 2016). Because mathematics anxiety and a negative mathematics orientation, in general, are related to negative memories, mathematics avoidance is common among adults (Hembree, 1990). Berkowitz et al. (2015) and Schaeffer et al. (2018) demonstrated how providing parents with self-guiding tools can help them circumvent their mathematics anxiety to improve their child's mathematics achievement.

In an experimental study of 587 first graders, Berkowitz and colleagues (2015) examined how *Bedtime Learning Together*, an iPad application containing number stories with pre-loaded questions, five questions each, increased parent involvement and student mathematics achievement. A secondary objective was to examine the application's effectiveness on the achievement of students who have parents with high levels of mathematics anxiety. The researchers also distributed iPad minis to 587 families and assigned 420 families from the 587 families to the treatment group, which received the tablet apps for mathematics story problems. The control group or the reading group consisted of 167 families who received the reading story problems. Berkowitz and colleagues (2015) tracked how frequently they used the applications during the school year, used a questionnaire to assess parent mathematics anxiety, and administered mathematics tests to assess student achievement.

Researchers found that children with parents with high mathematics anxiety showed achievement gains of three months over the reading group with parents with high mathematics anxiety ( $t = 1.99$ ;  $p = .048$ ). They also found that students with parents with high anxiety who used the application once weekly made significant gains over students with parents with high levels of anxiety who rarely used the mathematics app ( $t = 3.49$ ;  $p = .01$ ) (Berkowitz et al., 2015). Furthermore, researchers found no significant differences in the mathematics performances of students with low-anxious parents, who used the apps frequently or rarely. They reasoned that parents with low anxiety were more inclined to provide enriching mathematics activities at home since the frequency of app usage did not correlate to an increase in student mathematics achievement compared to students with math-anxious parents, who tend to avoid mathematics altogether (Berkowitz et al., 2016). Researchers demonstrated that iPad minis could facilitate engaging mathematics interactions between high-anxiety parents and their children and boost



mathematics achievement. These findings suggest that the intervention's success lay in tools that parents could readily use to guide their mathematics interactions with their children and help them circumvent their anxiety. Thus, increasing their motivation and confidence in providing more mathematics learning opportunities at home.

Schaeffer et al. (2018) were researchers from Berkowitz et al.'s (2015) study. Schaeffer et al. (2018) purposefully continued Berkowitz et al.'s (2015) study to examine the effects of parent mathematics anxiety and student mathematics achievement with the same families and sample size (N=587). Unlike Berkowitz et al.'s (2015) study, their main objective was to determine if the same app could eliminate the negative association between parent mathematics anxiety and student performances over two years. Similar to Berkowitz et al. (2015), Schaeffer et al. (2018) randomly assigned families to the mathematics story problem group (treatment group) and the reading story problem group (control group). Like Berkowitz et al. (2015), they administered a mathematics anxiety survey at the beginning and end of the year, assessed student achievement, and tracked app usage. Schaeffer et al. (2018) found that although families used the app less after first grade, the negative association between parent mathematics anxiety and student achievement to the end of third grade decreased due to a change in parent mathematics attitudes and improvements in the quality and quantity of interactions between parents and students.

Berkowitz et al.'s (2015) and Schaeffer et al.'s (2018) quantitative research designs did not examine in depth extraneous variables that may have increased student achievement. However, these randomized experimental studies of large sample size found a significant positive correlation between mathematics app usage for highly-anxious parents and student mathematics performances. These findings suggest that tools that scaffold mathematics

instruction through pre-loaded questions and stories may increase parent comfort with mathematics instruction in the process. There is an inverse relationship between parent self-efficacy and homework stress (Pressman et al., 2015), and providing parents with additional support may improve parent attitudes and confidence in supporting their children (Van Voorhis, Maier, Epstein, & Lloyd, 2013). Furthermore, according to Berkowitz et al. (2016) and Hembree (1990), math-anxious people tend to avoid mathematics. Thus, improvements in the mathematics performances of students with math-anxious parents suggest that math-anxious parents are more inclined to participate in their children's mathematics learning when provided with support. Thus, self-guided tools warrant inclusion in the intervention, specifically for the current parent population with easy access to technology and a demonstrated desire for resources that direct their reinforcement of the standards-based strategies.

### **Providing Emotional Support**

Jay et al. (2017) used four workshop sessions, each approximately 1.5 hours long, to increase the mathematics self-efficacy of approximately 15 parents of children, aged four through 11. Their primary objective was to use parent experiences and deconstruct narrow, school-centered parent views of mathematics to boost their mathematics confidence. The researchers provided emotional support by informing parent participants about their goal of improving their mathematics confidence and providing refreshments and opportunities to chat with other participants before the sessions began. In the first session, researchers permitted parents to share their insecurities about mathematics. They also empowered parents by positioning them as experts and themselves as the facilitators when they asked participants to share family activities and ways to identify mathematics in those activities. According to Knowles (1984), adults draw upon their experiences for learning, and Jay et al. (2017) allowed

parents to capitalize on their life experiences by discussing how mathematics is embedded in their daily life activities. In the second session, parents discussed daily activities that involve mathematics, and in the third session, parents discussed their mathematics conversations with their children. The last session examined the range of mathematics conversations parents had with their children.

Jay et al. (2017) recorded and transcribed the participants' conversations and determined that parents expanded their views of what constituted meaningful mathematics discussions. Through questioning and discussion, researchers gave "parents permission to try new ways of thinking" about mathematics (Jay et al., 2017, p. 218), and they learned how mathematics could involve multiple answers by the first and second sessions. By the third and fourth sessions, parents learned that finding exact answers, a source of stress in their mathematics discussions with their children, was not a requirement for quality mathematics interactions. Parents exhibited improved mathematics confidence when they reported creating mathematics games with their children, engaging in more mathematics conversations with their children, and no longer avoiding mathematics conversations. Like Jay et al. (2017), Tobon and Hughes' (2020) study improved parent mathematics self-efficacy by allowing participants to express their insecurities about mathematics and form connections between their knowledge and experience with mathematics and school instruction. In six 90-minute workshop sessions, two teachers led hands-on mathematics games for Latino families of third- to fifth-grade students. "To establish a safe place" for parents, the program included Spanish-speaking facilitators, team-building exercises, and opportunities for parental input as facilitators adjusted these sessions to meet parent needs (Tobon & Hughes, 2020, p.203).

Husain et al. (2016), unlike Jay et al. (2017), conducted a three-arm randomized control study with the parents of 2,592 students, aged seven to 11. Tutors delivered skills-based instruction in language arts classes (N=3) and mathematics classes (N=6) to examine the effects of parent attendance on student achievement. Husain and colleagues (2016) randomly assigned parent participants to the following groups: (a) those invited to attend (N=600), (b) those invited to attend with financial incentives of 30 pounds per session (N=500), and (c) those who were not invited to attend (N=1,900). Husain et al. (2016) found that the three groups did not exhibit a difference in student mathematics achievement, but their results revealed that parent participants had more confidence in their ability to more effectively participate in their child's mathematics learning. Using subject experts can increase parent mathematics knowledge, which can elevate parent mathematics self-efficacy levels.

Jay et al.'s (2017) qualitative study and Husain et al.'s (2016) mixed-methods study demonstrated various ways to increase parent mathematics self-efficacy. Parent participants had different roles in their studies, where parents were either positioned as the subject experts who drove the intervention (Jay et al., 2017) or as the primary receivers of information (Husain et al., 2016). Thus, these researchers showed that assigning parents different roles is effective depending on whether the objective is increasing parent knowledge of mathematics content (Husain et al., 2016) or helping them incorporate mathematics activities into their daily lives (Jay et al., 2017). Although increasing parent mathematics self-efficacy was a secondary outcome for Husain et al.'s (2016) study, they like Jay et al. (2017), provided emotional support by (a) providing refreshments, (b) encouraging collaboration, (c) easing parent discomfort about making mistakes, (d) helping parents connect their lives to school instruction, and (e) teaching mathematics skills.

Jay et al. (2017) and Husain et al. (2016) successfully provided emotional support to parents and improved their mathematics self-efficacy in the process. Therefore, the intervention will aim to meet this objective by positioning parents as experts (Jay et al., 2017) and as receivers of information (Husain et al., 2016). As experts, the parents will draw upon their experiences to support their child's learning. As receivers of information, the parents will learn mathematics strategies from their child and examples of strategies presented during their sessions. Collaboration, parent feedback, and providing parents with opportunities to express their discomfort with mathematics can also foster positive learning environments and increase parent self-efficacy (Tobon & Hughes, 2020; Van Voorhis, 2011a, 2011b; Williams & Williams, 2019). Thus, these components will be incorporated in the intervention because they are applicable to the current parent population, which is highly responsive to teacher engagement.

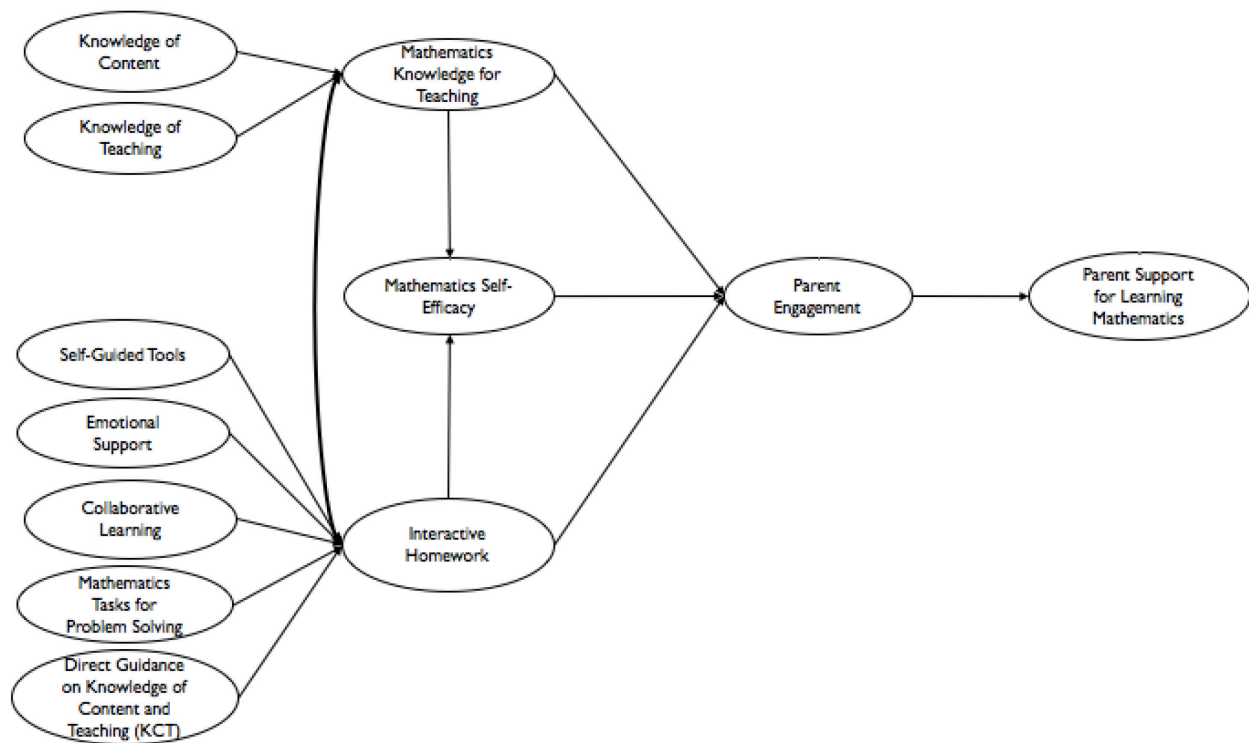
Bandura's (1986) triadic reciprocal determinism theory with his self-efficacy theory and Ball et al.'s (2008) MKT framework informed the interventions' examinations. These interventions demonstrated how the inclusion of specific environmental factors (e.g., collaborative learning, mathematics tasks for problem solving, direct guidance) improved KCT (personal factors) from Ball et al.'s (2008) MKT framework, which in turn improved parent mathematics self-efficacy (personal factors) and parent participation (behavioral factors). These interventions also featured self-guiding tools and emotional supports (environmental conditions) that increased parent mathematics self-efficacy and motivation (personal factors) to engage more effectively in their child's mathematics learning (behavioral factors). The next section provided an overview of the intervention that will aim to address parent mathematics knowledge for teaching and parent mathematics self-efficacy.

### **Proposed Intervention**

The proposed intervention seeks to improve parent mathematics knowledge for teaching and parent mathematics self-efficacy. Needs assessment results indicated that parents had varying levels of mathematics knowledge of instruction and content and a wide range of professions, suggesting limitations in their time and availability. Thus, although the workshop interventions, interactive homework interventions, and technology interventions were effective in improving parent mathematics knowledge for teaching and mathematics self-efficacy, the intervention that provides busy families with greater flexibility for engagement will incorporate components from the interactive homework interventions and technology interventions. Additionally, due to the COVID-19 pandemic, schools now engage in strict remote instruction. Thus, an interactive homework intervention is an appropriate intervention that can be conducted remotely in parents' homes, while allowing families greater flexibility for mathematics engagement.

A conceptual framework for the proposed intervention (Figure 3.3) contains connecting arrows that indicate the direction of relationships. Specifically, these arrows illustrate how self-guiding tools, emotional support, collaborative learning, mathematics tasks for problem solving, and direct guidance on KCT will be incorporated into the interactive homework assignment to influence mathematics knowledge for teaching and mathematics self-efficacy. The interactive homework assignment will contain word problems (mathematics tasks) and prompts (direct guidance on KCT) that directly guide and facilitate parent-child collaborations. The series of prompting questions (self-guiding tools) included in each assignment will help parents guide their learning process, and each assignment will include a feedback section (emotional support) that allows parents to discuss their experiences with the assignments and make suggestions for

improvement. The combination of these components may improve parent engagement, and thus their ability to support their children's mathematics learning.



*Figure 3.3. Conceptual Framework for Interactive Homework Intervention*

The proposed intervention will last at least four weeks with a task assigned once a week, similar to five interactive homework intervention studies that either increased parent instructional knowledge or parent participation (Balli et al., 1998; Loehr et al., 2014; Van Voorhis, 2011a, 2011b; Williams & Williams, 2019). The intervention's effectiveness in improving parent instructional knowledge and parent mathematics self-efficacy will be determined by pre-and post-surveys administered before and after the interactive homework intervention, similar to past interactive homework intervention studies (Van Voorhis, 2011a, 2011b; Williams & Williams, 2019).

## **Chapter Conclusion**

Ball et al.'s (2008) MTK framework and Bandura's (1986) triadic reciprocal determinism theory with his self-efficacy theory guided the examination of 20 interventions (Appendix B), which represented three major categories (e.g., workshop, interactive homework, technology). They were diverse in design, sample size, and duration, and therefore, an examination of these studies was required to identify essential components that improved parent mathematics knowledge for teaching and parent mathematics self-efficacy. Incorporating effective intervention features (e.g., collaborative learning, mathematics tasks, direct guidance, self-guiding tools, and emotional support) to form the interactive homework intervention may result in improved parent mathematics knowledge and parent mathematics self-efficacy. A study conducted to explore these program elements and their combined influence on parent mathematics knowledge for teaching and parent mathematics self-efficacy may achieve the program objectives of maximizing the effects of parent mathematics engagement.



## **Chapter Four**

### **Intervention Procedure and Program Evaluation Methodology**

Parent mathematics knowledge for teaching is analogous to Ball, Thames, and Phelps' (2008) mathematics knowledge for teaching (MKT) construct, knowledge of content and teaching (KCT), which “combines knowing about teaching and knowing about mathematics” to plan instruction (p.401). Mathematics self-efficacy is the belief that one will be successful in doing mathematics and mathematics tasks in general (Hackett, 1985). These constructs influence parent mathematics engagement and their ability to support their child's mathematics learning (Jay, Rose, & Simmons, 2018; Marshall & Swan, 2010; Remillard & Jackson, 2006). Needs assessment results revealed that barriers to parent mathematics knowledge for teaching (e.g., limited access to instructional resources, discrepancies between how they learned mathematics and current mathematics instruction) influenced their mathematics self-efficacy. Thus, parents who developed instructional knowledge often experienced improved confidence extending their child's mathematics learning (Husain et al., 2016; Jay et al., 2017; Tobon & Hughes, 2020).

### **Purpose of Study**

The purpose of this study was to determine in what ways parent participants can more effectively support their child's mathematics learning at home by increasing their mathematics knowledge for teaching and mathematics self-efficacy. Ball and colleagues' (2008) MKT framework and Bandura's (1986) triadic reciprocal determinism theory with the inclusion of his self-efficacy theory informed the examination of the intervention literature that led to the creation of the intervention. Parent mathematics knowledge for teaching and mathematics self-efficacy influenced their engagement and their environments, which in turn influenced their mathematics orientations (Knapp et al., 2016; Williams & Williams, 2011). Interactive homework assignments and technology interventions are particularly effective for achieving the

intended outcomes of improved parent mathematics knowledge for teaching and mathematics self-efficacy. The current study built on previous studies that evaluated the effectiveness of interactive homework assignments on parent mathematics knowledge for teaching and their mathematics self-efficacy (Van Voorhis, 2011a, 2011b; Williams & Williams, 2019).

### **Intervention Research Design**

The sections below described the intervention's theory of treatment (TOT), the process evaluation design, and outcome evaluation research design. The TOT describes the observable inputs and outputs of a program to highlight the relationships and processes that lead to its intended outcomes (Leviton & Lipsey, 2007). Process evaluations examine whether program activities and components have been implemented as designed, and outcome evaluations occur to measure a program's results and to determine how well it met its objectives (Rossi, Lipsey, & Henry, 2019).

### **Theory of Treatment**

Figure 4.1 illustrates the intervention's TOT, which contains the intervention resources and outcomes. The primary instrument for the intervention was the interactive homework. In alignment to the conceptual framework (Figure 3.3), the TOT illustrates how the interactive homework assignments incorporate five components (e.g., collaborative learning, mathematics tasks for problem solving, direct guidance on KCT, self-guided tools, emotional supports) to meet the short-term outcome, intermediate outcomes, and long-term outcomes.

The expected short-term outcome was improved parent-child mathematics discussions. Improvements in mathematics dialogue resulted when there were opportunities for engaging in problem solving (Mistretta, 2013; Williams & Williams, 2019), collaborating (Mangram & Metz, 2018; Papadopoulos, 2017), questioning (Westenskow, Boyer- Thurgood, & Moyer-Packham, 2015), and using tools (e.g., manipulatives, iPads) (Berkowitz et al., 2015; Panaoura,

2017; Schaeffer et al., 2018). The treatment involved these components using interactive homework as an instructional tool that contained probing questions that encouraged parent-child discussions as they problem solved.

The intermediate outcomes, expected to occur halfway through the intervention, were improved parent knowledge of conceptual computational strategies and increases in positive interactions during the homework sessions. The interactive homework assignment incorporates components that facilitated problem solving, such as collaboration, questioning, and tools that enhanced participant instructional skills and their learning environments in one session (Papadopoulos, 2017; Zippert, Daubert, Scalise, Noreen, & Ramani, 2019). Furthermore, when parent instructional knowledge developed, specifically in engaging children in mathematics discussions, positive interactions among parents and children increased (Mangram & Metz, 2018; Mistretta, 2013; Panaoura, 2017). The parent participant used the interactive homework assignments to guide her use of questioning, an instructional method, to promote discussion and knowledge of standards-based mathematics strategies. These questions likely promoted positive interactions as the parent and student followed prompts that facilitated respectful comparisons of strategies and solutions.

The long-term outcomes, expected to occur at the end of the intervention, were improved parent mathematics knowledge for teaching and mathematics self-efficacy. As Papadopoulos (2017) and Tobon and Hughes (2020) found, an increase in meaningful mathematics discussions and consistent exposure to mathematics strategies improved parent mathematics knowledge for teaching and mathematics self-efficacy in one session to six weeks of sessions. Participants had greater access to standards-based strategies through the word problems on the assignments and through problem solving together.

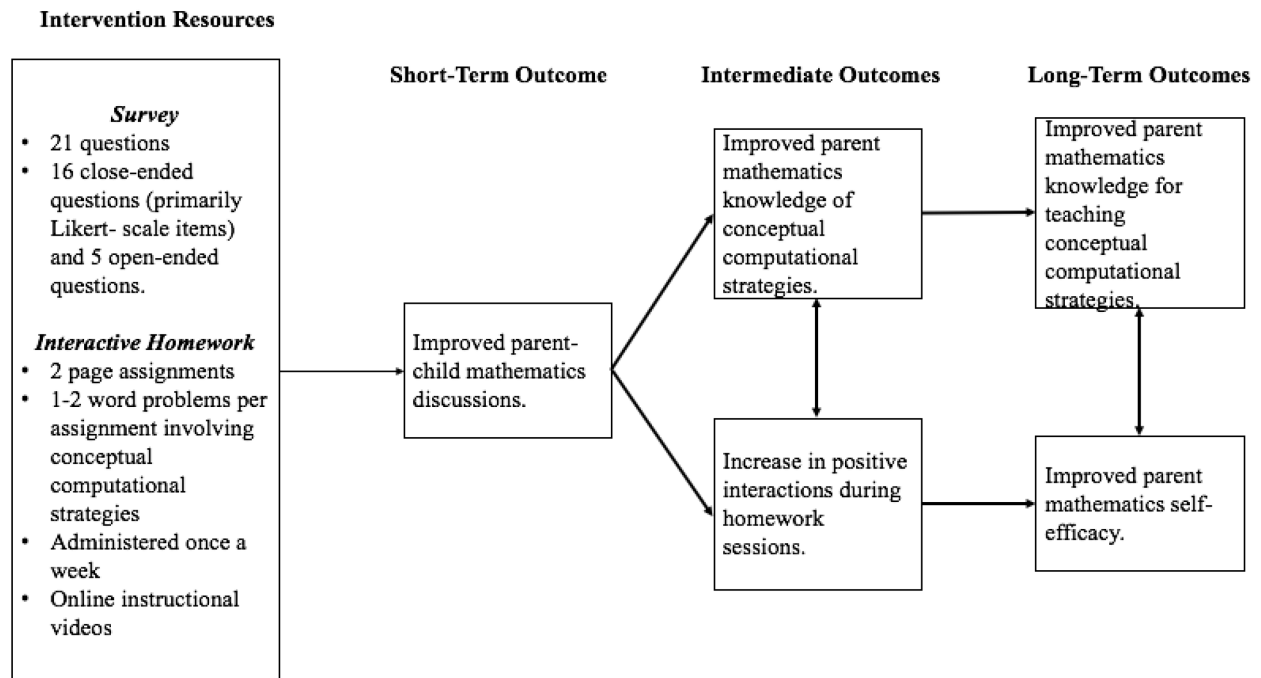


Figure 4.1. Theory of Treatment

## Process Evaluation

Process evaluations involve determining if the intervention was implemented with fidelity (Rossi et al., 2019), and project implementation, the degree to which the intervention occurred as designed and intended (Baranowski & Stables, 2000), was the prevailing construct used for determining if the intervention was implemented as intended. Poor implementation can yield poor results (Stufflebeam, 2003), and each stage of process implementation, if done with fidelity, should align to the TOT and logic model to result in the attainment of the program's overall objectives. Two questions (Table 4.2) guided the process evaluation.

**Table 4.2***Process Questions*

Process Question One	To what degree did participants complete and use the interactive homework as intended for six weeks throughout the intervention? ( <i>Program Implementation and Participant Responsiveness</i> )
Process Question Two	How did differences in participant characteristics and pandemic restrictions influence their contributions to the completion of the interactive homework assignments? ( <i>Context</i> )

Question one addressed the fidelity of implementation. All interactive homework assignments completed and submitted weekly for six weeks throughout the intervention would determine strong implementation. Participant access to and use of materials, as indicated by a 100% submission rate, is an important indicator of effective program implementation. The interactive homework assignments were the primary instructional tools that were intended to promote dialogue and collaboration between the participants while problem solving. Observing participants as they used these instructional tools also indicated the degree to which the intervention was conducted as intended. Submission rate and the ways in which participants used the interactive homework were important indicators of program implementation.

Question one also addressed participant responsiveness, which is the extent to which participants interact with and use program resources (Rossi et al., 2019). Resources were monitored and modified to increase participation (Saunders et al., 2005), and the interactive homework assignments were altered to address participant need. The successful program implementation for an at-home intervention requires that participants complete the interactive homework assignments without immediate guidance from the researcher, so the weekly

submission of assignments with all sections completed with fidelity indicates high participant responsiveness.

Question two involved context, environmental factors that can affect the intervention's implementation and outcomes (Saunders, Evans, & Josi, 2005). Understanding how these factors influence participation may provide information about the generalizability of the intervention in question (Baranowski & Stables, 2000). Context is also about developing an awareness of the target population to tailor the intervention to meet its specific needs (Stufflebeam, 2003). The capacity for managing and providing direct guidance to participants is limited because the program only occurred in the participants' homes. Thus, the impact of environmental factors is likely heightened because the researcher does not have immediate access to participants.

Participant characteristics are contextual elements that influence program implementation, and the typical parent within this context is highly engaged with significant mathematics experience and high levels of educational attainment. For example, according to needs assessment results, approximately 70% of online participants took college-level mathematics, 60% used high-skilled mathematics in their professions, and 93% of online needs assessment participants had a bachelor's degree or higher. Given their experiences and education, needs assessment results also revealed that some participants defer to their spouses to help their child with mathematics learning, suggesting that those most involved in their child's mathematics learning were considered the most-highly skilled family member in mathematics. Thus, parent characteristics (e.g., educational attainment, career, mathematics experience) can influence how participants engage with intervention materials.

The ways in which the COVID-19 pandemic influences parent engagement with the interactive homework assignments will also be examined. Although parents in this setting are

typically highly involved, current circumstances regarding the pandemic (e.g., remote instruction, balancing work-and-home life demands, access to technology, the ability to work from home) may reduce their participation. Parent characteristics and the ability to navigate pandemic restrictions are contextual indicators that will likely influence participant engagement with program materials and affect program implementation.

The logic model (Figure 4.2) served as a guide for successful program implementation, aligning to the conceptual framework (Figure 3.3) in its overview of how major stakeholders (e.g., parents, students) used the interactive homework to meet program outcomes. The interactive homework assignments were created and emailed to participants with the objective of parent participants collaboratively problem solving with their children and emailing the completed assignments to the researcher. Observations were conducted of participants using the assignments over Zoom. These assignments were reviewed and monitored to assess participant learning and their experiences with the assignments to determine the extent to which outcome and process objectives were achieved.

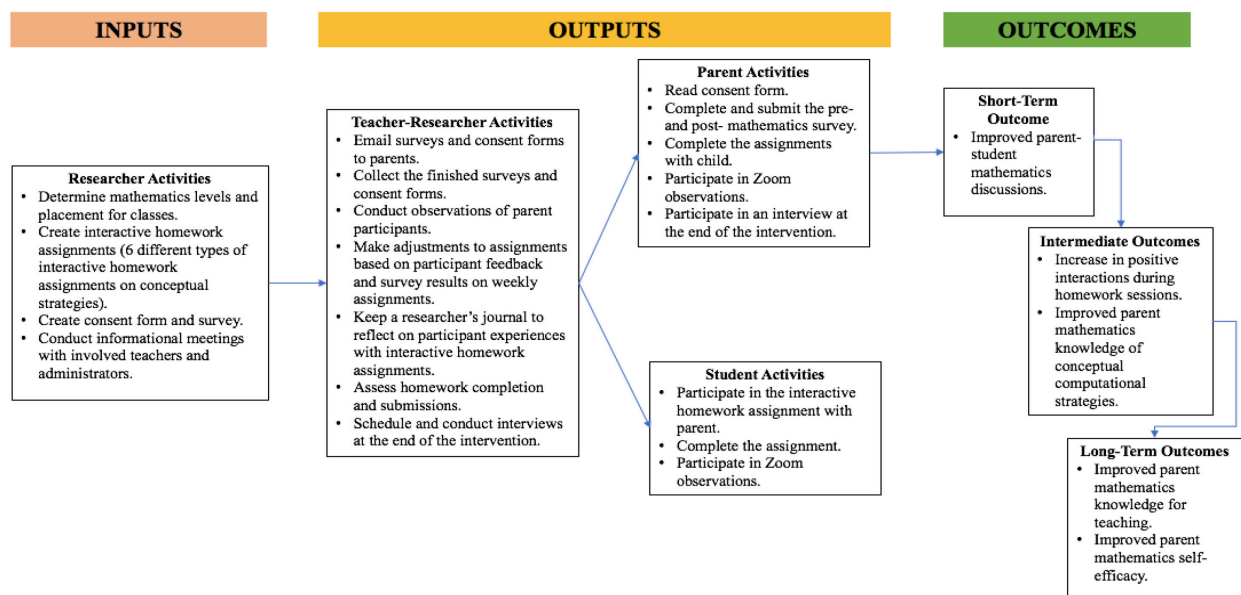


Figure 4.2. Logic Model

## **Outcome Evaluation**

Outcome evaluations determine the extent to which an intervention met its intended outcomes, and for research purposes, determines the relationship among constructs (Rossi et al., 2019). Three questions were used to examine the impact of the interactive homework intervention on parent mathematics knowledge for teaching, parent mathematics self-efficacy, and their views of the interactive homework program (Table 4.3). The program's impact was assessed with a case study design, which allows for a phenomenon to be examined in greater depth in real-world conditions when barriers blur between the phenomenon and real-world conditions (Yin, 2003; Yin, 2018). Given the significant reduction in parent participants from the pre-pandemic needs assessment study (N=67) to the current study (N=1), pandemic restrictions (e.g., quarantine, remote instruction) likely reduced interest in the intervention study and likely continued to influence participant behavior. Specifically, a case study design can account for and capture the pandemic's impact on participant behavior, in addition to their mathematics engagement.

There are also several forms of case studies (e.g., single-case holistic designs, single-case embedded designs, multi-case holistic designs, and multi-case embedded designs) (Yin, 2018). A single-case holistic design was used for this study. Single-case holistic designs are akin to "single experiment" designs (Yin, 2018, p. 49), and they are ideal for examining unusual phenomena (Yin, 2003; Yin, 2018). Examining mathematics engagement confined to the home under pandemic restrictions qualified as an unusual event.

The constructivist paradigm serves as the philosophical foundation for case studies (Baxter & Jack, 2008). This paradigm emphasizes the collection of qualitative data, non-numerical data (Johnson & Onwuegbuzie, 2004) for deeply examining participant experiences



(Baxter & Jack, 2008; Yin, 2018). According to Johnson and Onwuegbuzie (2004), qualitative data is often collected for studies of smaller sample size, a criterion this study fit. To improve the trustworthiness of a qualitative research study, an assortment of data sources is also collected to triangulate findings and more accurately capture participant experiences (Guba, 1981; Krefting, 1991; Lincoln & Guba, 1985). A survey containing open-ended questions, participant comments on the feedback and writing sections of the interactive homework assignments, observations, the researcher's journal, and the interview were used to assess the program's impact on parent mathematics knowledge for teaching, parent mathematics self-efficacy, and their identification of helpful program features.

Table 4.3

*Outcome Questions*

Outcome Question 1	In what ways does the homework intervention change perceived parent participant mathematics self-efficacy?
Outcome Question 2	In what ways does the homework intervention change perceived parent participant mathematics knowledge for teaching?
Outcome Question 3	What components of the interactive homework assignment program do parent participants identify as useful in helping them help their children with mathematics learning at home?

**Intervention**

Two teachers managed initial program implementation, which was planned for six weeks. The two teachers administered a survey (Appendix F) to approximately 80 parents and consent forms electronically to measure the constructs of parent mathematics self-efficacy, parent mathematics knowledge for teaching, and participant characteristics. The participants were

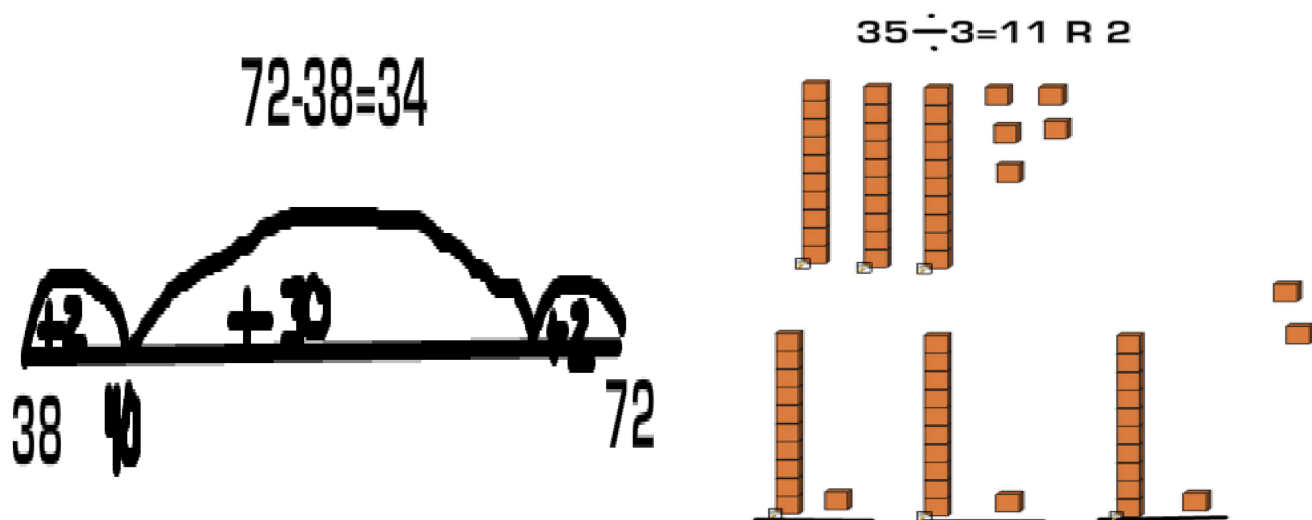
expected to indicate their intent to participate by emailing the completed survey and consent forms to the researcher, whose contact information was provided in the emails sent by the two teachers. Due to the COVID-19 pandemic, only one family decided to participate in the intervention. The parent-child dyad received emails containing intervention materials (e.g., the six interactive homework assignments), in which they worked collaboratively to complete. Additionally, the participants were observed by the researcher using the interactive homework over Zoom, a video conference tool. At the end of the intervention, after the last homework assignment and observation transcript had been collected and analyzed, an interview was conducted with the parent to gain additional insight into her experiences with the interactive homework intervention.

## **Method**

The sections below described participant population, participant recruitment, the intervention design, and materials. A variety of materials were used for intervention implementation.

### **Participant Population**

The parent and child participants represent a population that attends an affluent, suburban elementary school in Maryland. The intervention aimed to improve parent mathematics knowledge for teaching and mathematics self-efficacy with instructional tools that address conceptual computational strategies, which the CCSSM emphasize (CCSSO & NGA, 2019). These strategies (e.g., the counting up strategy, the equal shares model) (Figure 4.3) provide students with a more concrete understanding of computation (CCSSO & NGA, 2019).



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Figure 4.3. Conceptual Strategies

According to needs assessment results, parent participants noted an unfamiliarity with these strategies and insufficient resources that could help them learn these strategies. Thus, the primary participant was the parent, a guardian of a student taking fourth-grade level mathematics classes, which address conceptual strategies for computation.

### Participant Recruitment

Purposive sampling, the selective recruitment of participants based on specific characteristics that affect causal relationships in the study (Campbell, Cook, & Shadish, 2002), was used to ensure that the participants chosen were parents of students taking fourth grade-level mathematics with similar mathematics abilities and standards. Parent participants were also recruited from two mathematics classes that represented the same mathematics level.

Recruitment occurred through emailing surveys and consent forms about the intervention to parent participants. Although the parent was the focus of the intervention, Zoom observations of the parent and student using the interactive homework assignments, required that the student also complete consent forms. These consent forms contained information about the responsibilities of participation and information about the intervention's objective of assessing the interactive homework assignments' effectiveness in improving parent mathematics knowledge for teaching and parent mathematics self-efficacy.

### **Study Design**

Due to the COVID-19 pandemic, the sample consisted of a parent-child dyad, which required a design change from a quasi-experimental concurrent mixed methods study to a descriptive, single-case holistic case study. This specific case study design is appropriate for examining one unit of analysis (parent participants) that are influenced by real-world contexts (Yin, 2003). As Figure 4.4 illustrates, parent mathematics knowledge for teaching, mathematics self-efficacy, and parent characteristics can influence the intervention, which in turn affects their ability to provide effective mathematics support. As the connecting lines in Figure 4.4 demonstrate, parent and student work on the interactive homework assignments, observations, the researcher's journal, and the interview measured potential differences in perceived parent participant mathematics self-efficacy and perceived mathematics knowledge for teaching. A survey also measured participant characteristics, which include their occupations and experiences.

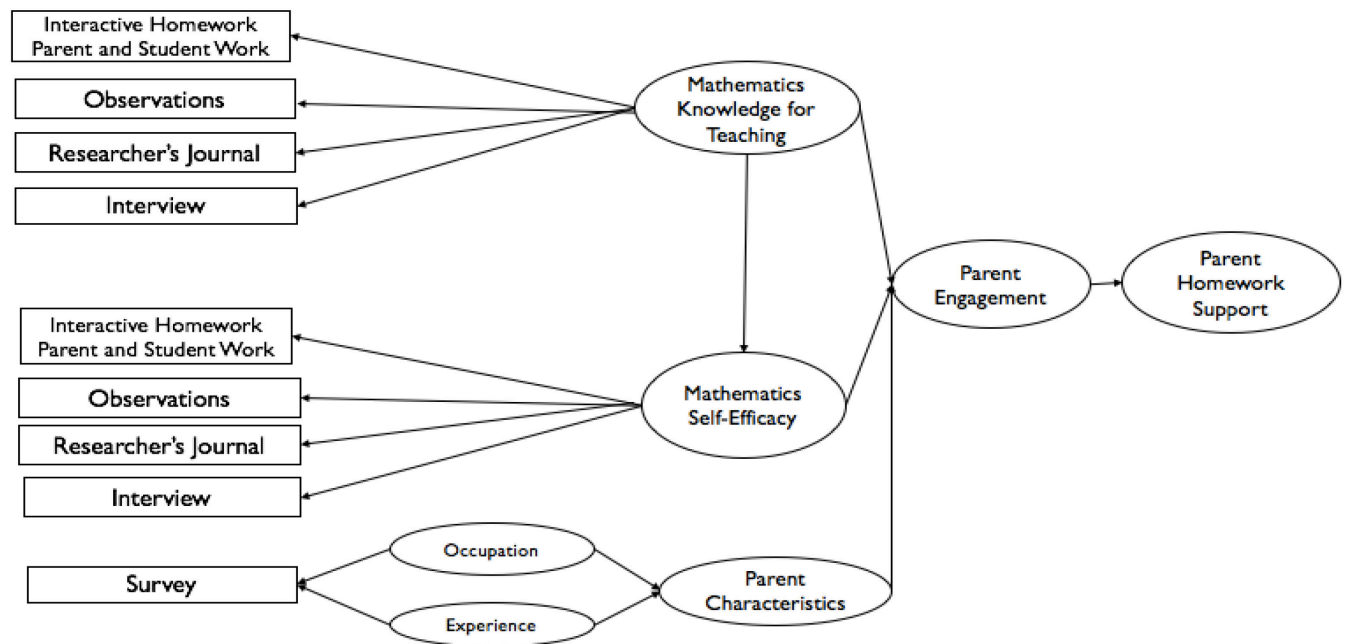


Figure 4.4. Measurement Conceptual Framework

## Materials

The interactive homework assignments (Appendix E) were the primary materials used to meet the long-term outcomes of improved parent mathematics knowledge for teaching conceptual computational strategies and parent mathematics self-efficacy. The researcher created the assignments, and each assignment was reviewed by mathematics specialists at the University of Kentucky (UK). These documents consisted of a word problem section, discussion section, writing section, and a feedback section.

The word problem section contained (a) a word problem or prompt, (b) side-by-side examples of strategies, (c) a list of problems to solve using the strategies, and (d) two areas designated for the parent participant and student to problem solve using their strategies. Within this section was also a series of probing questions (N=3) to facilitate discussion of student and parent solutions and strategies. Participants completed the discussion section that contained questions (N=2-3) to help them gain more insight into the relationship between their strategies

and problems. The writing section contained questions (N=2-3) to encourage the adult participant to compare and contrast strategies and deepen her understanding of conceptual strategies. The feedback section also contained statements (N=4) that the adult participant selected to describe student progress on the assignment. This section also contained an area that encouraged the adult to elaborate on her and the students' learning experiences using the assignments and provide suggestions for future assignments.

### **Data Collection and Analysis**

A survey, interactive homework assignments, observations, and the researcher's journal were created to assess the effectiveness of a six-week intervention on parent mathematics knowledge for teaching and mathematics self-efficacy. These items served as data sources for outcome questions one, two, and three. Additionally, at the end of the intervention, an interview was conducted to address outcome question three, which required the adult participant to identify the most useful components for improving their mathematics engagement.

#### **Survey**

The first data instrument, a researcher-created survey (Appendix F) was created for measuring changes in parent mathematics knowledge for teaching and parent mathematics self-efficacy. The survey served as a tool administered before the intervention because it was a recruitment tool intended for a larger sample size with 21 questions, 14 of which were Likert scale items. The response scale was from one to five, ranging from *strongly agree* to *strongly disagree* (e.g., I can support my child in all his/her mathematics homework. I can help my child draw pictures and use objects to model addition of whole numbers.).

The survey also contained five open-ended questions (e.g., "Describe your experiences working with your child in mathematics."; "Through what grades, do you feel you could help

your child with mathematics?”) to serve as a source of qualitative data for examining perceived changes in parent mathematics knowledge and mathematics self-efficacy. A mixture of a priori and emergent coding was used for analyzing participant responses.

The survey was also reviewed by the UK faculty, who evaluated the homework activities. There were several iterations of the survey, which was passed back and forth between the researcher and the UK faculty. Lastly, the survey’s credibility was improved when additional adjustments were made based on the results from three cognitive interviews conducted with parents of elementary-school students, who were not involved in the intervention.

### **Interactive Homework Assignment**

The interactive homework (Appendix E) served as an additional qualitative data source. After the participant emailed the completed assignment at the end of each week, the assignment was assessed for improvements in instructional knowledge based on the correct use of conceptual strategies and how accurately the adult participant explained her and the student’s reasoning for using the conceptual strategies. The writing and feedback sections of the assignments were additional sources of qualitative data for examining the nature of the adult participant’s responses, including her explanations for selecting strategies and descriptions of her problem-solving experiences with her child. A priori and emergent coding were used to analyze these responses.

### **Observations**

Every two weeks, participants were observed over Zoom using the interactive homework materials, and a journal was kept to reflect on parent-child interactions and their use of the interactive homework assignment. Follow-up observations were conducted when required to provide greater clarification on participant experiences using these assignments. The participants

were observed on the following components: (a) use of conceptual strategies, (b) arrival at correct answers using conceptual strategies, and (c) their explanations for their selection and use of strategies. The degree to which the participants used the discussion prompts embedded in the interactive homework assignments and the nature of their discussion of strategies based on their use of interactive homework assignments, were carefully monitored to determine how to modify the assignments. A priori and emergent coding were used to examine this data source.

### **Researcher's Journal**

A journal was updated weekly that contained the researcher's analysis of the Zoom observations and completed interactive homework assignments (e.g., how conceptual strategies were selected and used, parent feedback). The following questions were answered weekly: (a) "Was the interactive homework assignment for this week effective? Why or why not?", (b) "Did the participants use the interactive homework as intended? Why or why not?", (c) Should adjustments be made to the format of the interactive homework assignments? Why or why not?", and (d) "How did my interactions with the participants influence their use of intervention materials?" A priori and emergent coding were used to analyze entries.

### **Interview**

An interview with the parent participant occurred at the intervention's end using Zoom. The initial questions were (a) "How would you describe your overall experiences using the interactive homework?", (b) "How were you able to complete the homework?", (c) What did you like/not like about the homework questions?", (d) What did you find difficult/too easy?", and (e) "Are there any suggestions that you would like to add to help improve the interactive homework assignments?"



Follow-up questions (e.g., “How have the interactive homework assignments influenced how you think about Common Core strategies?” or “Please elaborate on how the interactive homework assignments influenced how you and Nikita communicate about mathematics and problem solving.”) were also asked to clarify participant responses. This interview provided qualitative data in the form of participant describing her experiences using the interactive homework assignments. The interview was transcribed, and a priori and emergent coding were used to analyze responses to measure the outcome of the intervention.

### **Chapter Summary**

Guided by needs assessment findings, Ball and colleagues’ (2008) MKT framework, Bandura’s (1986) triadic reciprocal determinism theory with the inclusion of his self-efficacy theory, and intervention literature on parent mathematics instructional knowledge and parent mathematics self-efficacy, an interactive homework intervention was created to improve parent mathematics knowledge for teaching and parent mathematics self-efficacy regarding conceptual strategies. Process and outcome questions also guided the creation of the descriptive single-case holistic design case study, its implementation, and data collection and analysis. There is limited empirical evidence on factors that affect parent mathematics knowledge for teaching and parent mathematics self-efficacy and their overall mathematics engagement in upper-elementary school. Thus, the overall objectives of the study were to understand how the interactive homework intervention influenced parent mathematics knowledge for teaching and mathematics self-efficacy and to identify intervention components that the participant found helpful in developing her child’s mathematics learning.

Parent participants, the recruitment process, and data collection were also described. Understanding how parent characteristics influence how they use program materials was another consideration for future studies on mathematics knowledge for teaching and mathematics self-

efficacy. Data collection in the form of a survey, interactive homework assignments, observations, a researcher's journal, and an interview were created to determine if parent mathematics knowledge and mathematics self-efficacy changed, and if so, how they changed. An overview of an interview was provided to illustrate how the participant provided additional information on her homework experiences that may influence future intervention studies. Overall, these data sources served to provide information on the relationships among constructs to identify the most effective intervention components for improving parent mathematics engagement for future studies.

## **Chapter Five**

### **Intervention Implementation**

This chapter is about the context, participants, researcher, and program implementation. In addition, this chapter aims to connect the theoretical frameworks to the study's findings. Furthermore, the study's summation and limitations with implications for future research are provided in the conclusion.

### **Context**

#### **Participants**

Due to COVID-19 restrictions (e.g., quarantine, remote instruction), a descriptive, single-case holistic case study design was used to examine mathematics engagement in the home of a White parent of two children, one of which is a fourth-grade student enrolled in fourth-grade level mathematics in an affluent, suburban elementary school in Maryland. For this study's purposes, the parent participant will be called Linda, and the child participant will be called Laura Jean. Linda has a master's degree in social work, and her mathematics background is extensive, having minored in mathematics in college. She chose to participate in this study to learn conceptual mathematics strategies as the parent who primarily helps her children with mathematics.

School district initiatives led the transition from in-class instruction to remote instruction. These changes resulted in additional challenges (e.g., differentiating instruction, limitations in student collaborations, technical difficulties) in supporting Laura Jean's learning. Thus, this research study reflects the challenges participants encountered when learning mathematics at home during a global pandemic.

#### **Researcher Identity**

This study was conducted by Laura Moore, a national board-certified educator with eight years of teaching experience. She is African American from a southern family and is third-generation college-educated. She would be considered middle class. Although Laura differs in race from the participants, similarities in social class and formal education reduced power imbalances between the researcher and parent participant. Furthermore, Linda is culturally aware and responsive, due to her work as a social worker with extensive experiences and relationships with people of color. Given these factors, trust was quickly established between the researcher and the parent participant.

### **Program Implementation**

This six-week case study began when parent participants were recruited with surveys about their experiences and backgrounds with conceptual mathematics strategies. One parent, Linda, demonstrated interest after a month and a half of recruitment by teachers on Laura's fourth-grade mathematics team, who sent her emails to their own mathematics classes to maintain researcher objectivity. After Linda and Laura Jean completed the required documents, Linda was emailed the interactive homework assignments containing addition and subtraction problems for completion at the end of each week. Zoom observations, approximately 30 minutes in length, were conducted of participants using the interactive homework assignments. Although these observations had initially been scheduled for every two weeks, follow-up sessions were conducted weekly for clarifying purposes. A final Zoom session was used to interview Linda about her experiences with the interactive homework assignments. Finally, a reflective journal was kept by the researcher throughout the intervention. All sources, parent comments on the survey and interactive homework assignments, transcripts of observations, the researcher's journal, and the interview transcript, were analyzed and coded. The sections below outline each

week of the interactive homework assignments and the sample problems, which informed what strategies the participants used and discussed.

### **Week One**

Linda and Laura Jean completed the first interactive homework assignment (Figure 5.1) containing the traditional algorithm and the adjustment strategies for subtracting whole numbers. The traditional algorithm was an option to help the parent participant connect her mathematics understanding to the conceptual strategy being explored. In addition, the problems were designed to be more readily solved with a particular strategy to help Linda discern how conceptual strategies functioned to deepen student mathematics understanding. Problems were placed side-by-side for comparison to facilitate participant discussion of strategies to reinforce their understanding. After participants were encouraged by question prompts to compare and contrast strategies, they were instructed to choose and solve two problems each. Each problem lent itself to a strategy deemed more appropriate to help participants identify each strategy's strengths and weaknesses and develop their understanding of each strategy's purpose. For example,  $500-345$  and  $400-289$  were presented as more conducive to the adjustment strategy. The adjustment strategy required modifying each minuend, the number being subtracted (e.g., 500, 400), and subtrahend, the subtracting number (e.g., 345, 289) to simplify the problem-solving process by eliminating the need to regroup. For this study, regrouping is defined as the process of breaking down a larger value to exchange it for its equivalent at a smaller place value (i.e., swapping a ten for ten ones).

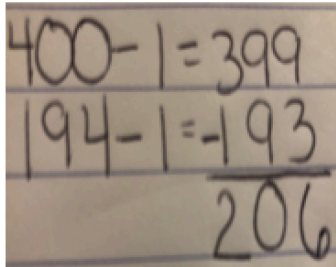
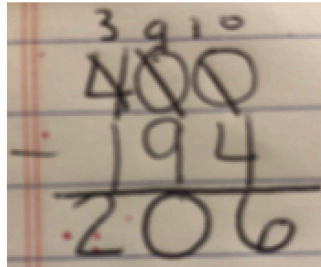
Sharmeen and Daniel approached the problem 400-194 in different ways. Study their examples below.	
<p><i>Sharmeen used the adjustment strategy to solve.</i></p> 	<p><i>Daniel used the traditional algorithm to solve.</i></p> 

Figure 5.1: Interactive Homework Assignment One

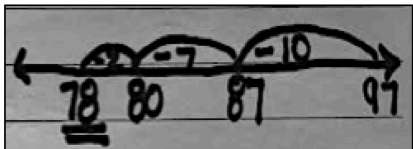
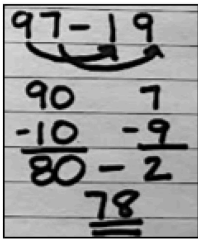
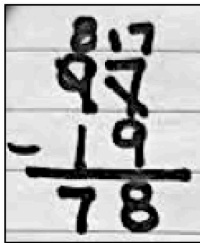
Three of the four problems were solved correctly because Linda did not solve the last problem, 452-167. Linda's response to the writing section question, "What were the advantages of each strategy?" was limited to a sentence, "Guess there are less steps in Adjustment but it can't be used in every problem and requires more thinking." Her response also contained few words for the question, "Was there one strategy that was more efficient than the other for a given problem? Why or why not? Please explain." She wrote, "Yes, couldn't figure out adjustment for parent's second problem. Child enjoys the traditional [algorithm] and didn't want to do adjustment." Based on the assignment directions, the child participant selected two problems for solving that were intended for use with the adjustment strategy, leaving two problems for Linda to solve that were unsuitable for the adjustment strategy. Therefore, Linda could only complete one problem out of the required two. Lastly, Linda did not elaborate on her experiences in the assignment's parent feedback section. As a result, an observation using Zoom was scheduled for the second session to gather information on participant experiences using the assignments and to modify the assignments to provide better guidance on how to use them as intended.

## Week Two

Linda received the second assignment (Figure 5.2), which included three strategies, *removal*, *partial difference*, and the *traditional algorithm*, and this assignment was

tailored to meet Linda's needs by providing more opportunities for her to choose problems suitable for solving with the designated strategies. For example, five problems were available for Linda and Laura Jean to solve instead of the four problems that were originally included in the first assignment. The assignment directions were also changed to instruct Laura Jean to select one problem, followed by Linda choosing a problem, followed by the other. This change addressed the issue from the first week of Laura Jean choosing the only problems that were appropriate for one strategy while leaving Linda with the only option of solving using the traditional algorithm, the only strategy she knew. The traditional algorithm was also included to serve as Linda's foundation for understanding the conceptual strategies, removal and partial difference.

**Nabeela solved a word problem, which required her to do  $97-19$ . She used Removal, Partial Difference, and the Traditional Algorithm.**

<i>Removal</i>	<i>Partial Difference</i>	<i>Algorithm</i>
		

*Figure 5.2: Interactive Homework Assignment Two*

A Zoom observation of approximately 30 minutes was conducted with the participants engaging in the word problem section. In this section, they reviewed the strategies from the sample provided and selected problems to solve with strategies that were best suited for solving them. Assignment modifications improved Linda and Laura Jean's use of these assignments. They alternated in choosing their problems, improving Linda's explanations of why she chose

her problems and why those strategies were appropriate. They solved all the problems correctly, but Laura Jean required significant assistance. Linda frequently corrected Laura Jean's habit of reversing the minuend and subtrahend to avoid regrouping. This session was also characterized by Laura Jean's one-to-three word responses and shrugs and Linda correcting Laura Jean's mistakes by repeating and demonstrating the traditional algorithm's procedures. Throughout the session, Linda discussed her preference for the algorithm due to its systematic process, which reduces the amount of thinking required in problem solving. She also frequently remarked how conceptual strategies' processes could vary widely, specifically stating how they require "extra thinking." Laura Jean, mirroring her mother, also displayed an evident preference for the traditional algorithm, although she required frequent corrections for performing this strategy incorrectly.

Linda's comments on the assignments supported the researcher's observations of Linda's appreciation of the traditional algorithm and Laura Jean's confusion when problem solving. In response to the writing section question, "What were the advantages of each strategy?" Linda wrote, "traditional algorithm = straight forward and no extra thinking on it if it would work." She did not provide an advantage for the conceptual strategies. In response to the second writing question, "Can you predict which strategies would work best with these problems based on inspection? Why or why not?" she wrote, "I could but Laura Jean couldn't and she didn't fully understand why."

### **Week Three**

A follow-up session was required to determine the interactive homework's effectiveness because the participants indicated misunderstandings and challenges using the strategies. For example, Laura Jean continued to reverse the minuend and subtrahend when the problems



required regrouping, and Linda's attempts to correct her consisted of repeating the traditional algorithm's procedures rather than explaining why regrouping was required. As a result, the following interactive homework assignment (Figure 5.3) was embedded with visuals of regrouping next to the traditional algorithm to correct Laura Jean's confusion. Laura Jean's continued reversal of the minuend and subtrahend illustrated how she did not understand the meaning of subtraction and how an exchange of numbers (e.g., one hundred to ten tens, one ten to ten ones) is required when the minuend is smaller than its subtrahend. Attempting to follow the traditional algorithm's procedures without concrete understanding resulted in her continued error in using this strategy. Thus, visuals were included to promote tangible regrouping of base-ten blocks to improve Laura Jean's understanding of subtraction and develop Linda's conceptual understanding of subtraction.

Shanyka solved two word problems, which required her to do  $33-19$  and  $13-6$ . She used base-ten blocks and the traditional algorithm.

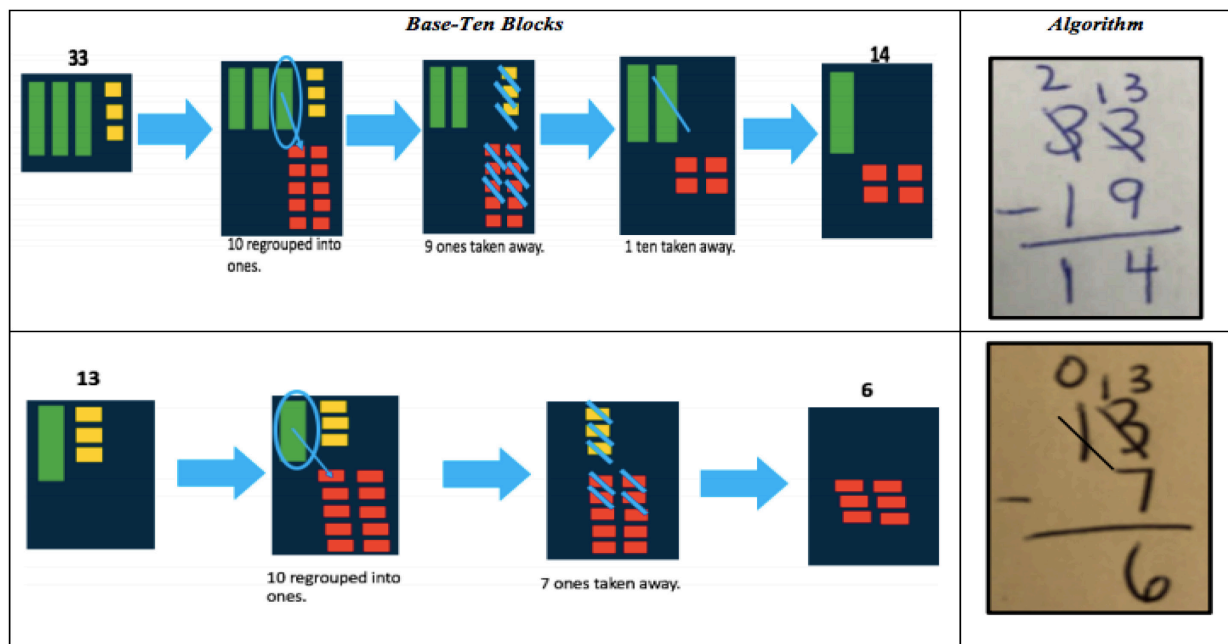


Figure 5.3: Interactive Homework Assignment Three

Within the first two seconds of seeing the assignment's strategies, Laura Jean remarked, "Yeah, no sense. This makes no sense," and proceeded to select problems to solve without first studying the side-by-side examples, prompting Linda to state, "I need to figure out what how we're doing it first, we can't step jump down here yet." Linda attempted to redirect her to the sample problems, using the assignment's "Quick Take" questions (e.g., What do you notice? What do you wonder? How are these strategies related?). When Laura Jean did not respond, Linda described what was in each section without providing an explanation for the base-ten block models. After the researcher encouraged Linda and Laura Jean to study the strategies longer, Linda continued to struggle to identify a connection between the base-ten blocks and the traditional algorithm, asking her daughter, "I don't understand why this is...why this is circled and why a line is draw here. Do you know?" Laura Jean replied, "Don't understand it." After a few minutes of productive struggle, the researcher explained the side-by-side comparisons of 33-19, and how one cannot remove 9 ones blocks from 3 ones blocks, prompting the need to decompose 1 tens block into 10 ones. With that explanation, Linda indicated understanding and repeated this explanation to her daughter:

So this way to visually see it...you need to take this right here and turn it into 10 dots.

Okay, okay...so cross it out and turn it into 10 dots. Okay, so now, you can take away.

How many? How many dots you have there?

While Laura Jean was initially confused, she appeared more interested in solving after the visual method was further explained. As Laura Jean used the base-ten model for solving, Linda encouraged her newly-found initiative with the following responses, "There you go. You get that? Kind of? Let's do another one like that." The session began to shift from a parent-driven monologue, in which Linda was directing the problem-solving process, to dialogic as she began

to ask guiding questions and make suggestions as her daughter responded and solved: “That's what you crossed off... Right? So how many do you have left that you didn't cross off?” or “If you want to, use your other color [markers to] help see. Okay.” Laura Jean surprised Linda by opting to complete all of the problems to which Linda replied, “Are you just gonna [*sic*] do all the problems for me?” She also stated how solving appeared to be easier for her daughter, “Like this is easy.” As Laura Jean’s understanding of conceptual strategies appeared to develop, Linda also demonstrated a greater understanding of these strategies with comments that were focused on explaining the visual process of regrouping, “Okay, so how many [tens do] you have? I know that each of those ways you know. You don't count those numbers. That's what you were crossing off,” as Laura Jean solved the problems.

Linda's responses on the writing section of the third week's homework appeared to align with what occurred during the observation that demonstrated her greater understanding of conceptual strategies. She also completed the assignment writing section and wrote a response in the assignment's discussion section, which did not require a written response. She recognized that the base-ten model showed how to regroup and did not include the traditional algorithm’s advantage as she did in previous homework responses. In addition, this was the first assignment that she wrote a response to the discussion question, “How did your partner help you learn about the strategies (e.g., encouragement, providing a great explanation).” She noted how Laura Jean helped her, “Stop and think and double check steps,” further acknowledging what occurred in the observation as Laura Jean’s participation increased.

#### **Week Four**

The week four assignment (Figure 5.4) included three strategies, one of which was a source of confusion for Laura Jean, the adjustment strategy from the week one assignment

(Figure 5.1). A number line was included with the adjustment strategy for additional guidance. Additional modifications were made by eliminating the traditional algorithm because Linda appeared to no longer require the traditional algorithm for support when she demonstrated a greater understanding of conceptual strategies from week one to week three. To further encourage Linda's use of conceptual strategies, the assignment included three conceptual strategies instead of one conceptual strategy and eliminated the traditional algorithm, her preferred strategy for solving.

**Katherine solved a word problem, which required her to do 60-49. She used base-ten blocks, removal on a number line, and adjustment on a number line.**

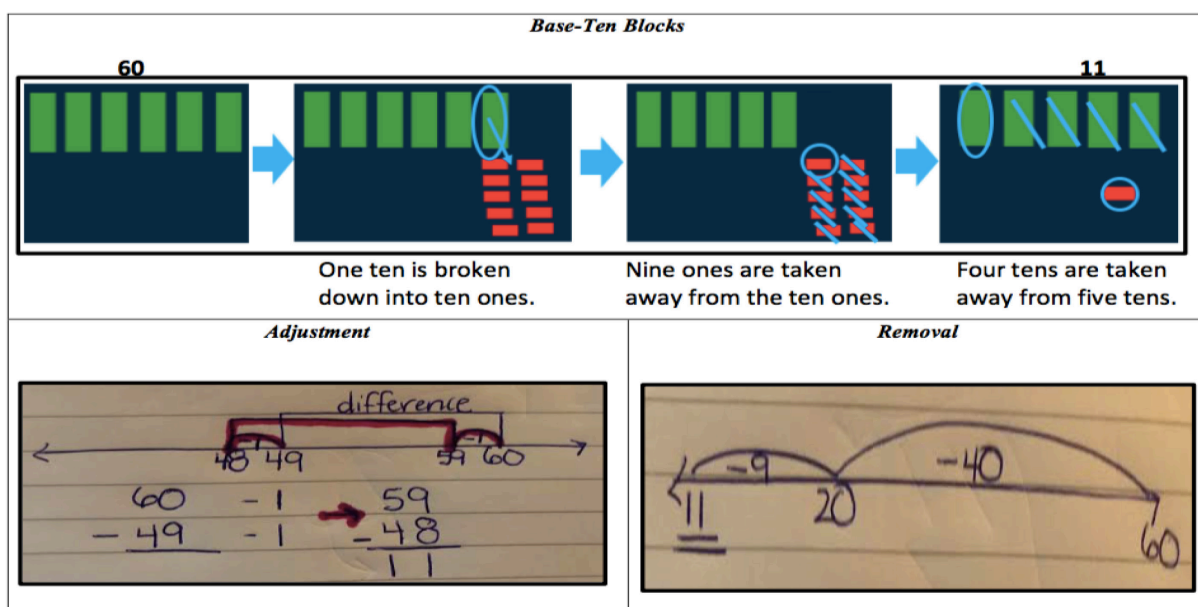


Figure 5.4: Interactive Homework Assignment Four

The session began with Linda relying more on the discussion prompts within the homework for the first time in the sessions. Specifically, she read the prompts directly from the homework, unlike in previously observed sessions where they quickly reviewed the examples and started solving. In response to Laura Jean saying, "I'm doing this problem," Linda stated, "We're not doing anything yet. We're looking at them...What do you see? What do you notice?"

As the session progressed, Laura Jean began to respond with extended answers that contained mathematical language, contrary to previous sessions in which her responses generally ranged from one to three words. Laura Jean stated, “So they had 60 and then they minus one. And then they minus one,” while Linda made additional connections to previous interactive homework assignments, “Okay, so that’s...[what] we did that on the first assignment, right? This is showing our number line.” After that problem was solved correctly, Laura Jean selected another problem, while Linda continued to refer to previous assignments, stating how she should select adjustment, “I think the adjustment [strategy is the right] one. We’ve used the ones with [numbers that end in] zeroes... 90 and 80.” Laura Jean’s initial confusion about the adjustment strategy subsided as Linda explained why the adjustment strategy is an appropriate strategy to use for avoiding regrouping, directing her attention to the base-ten model of regrouping to further explain.

In this session, Linda’s orders transitioned into guidance and encouragement as Laura Jean’s motivation to solve grew. Dialogue also occurred where Linda reviewed the problems and began to explain them. She referenced the previous assignments’ strategies to support her selection of problems and the strategies used for solving them.

### **Week Five**

At the end of session four, Linda discussed her concern about Laura Jean’s confusion about fractions, specifically the part-to-whole relationship. Linda also stated how Laura Jean felt confident with subtraction with whole numbers after learning the conceptual strategies from the previous assignments. Thus, interactive homework assignment five was designed to address Linda’s concerns about Laura Jean’s struggles with fractions with the inclusion of the number line and area model strategies to illustrate addition, and the traditional algorithm, which served as

a point of reference for Linda (Figure 5.5). The assignment also contained a word problem to further promote conceptual understanding with strategies that modeled the real-world scenario.

Nabeela, Shanyka, and Katherine reviewed and solved the word problem below using different strategies:

*Raro ran 1/5 of a mile. Cassie ran 2/5 of a mile. How far did they run?*

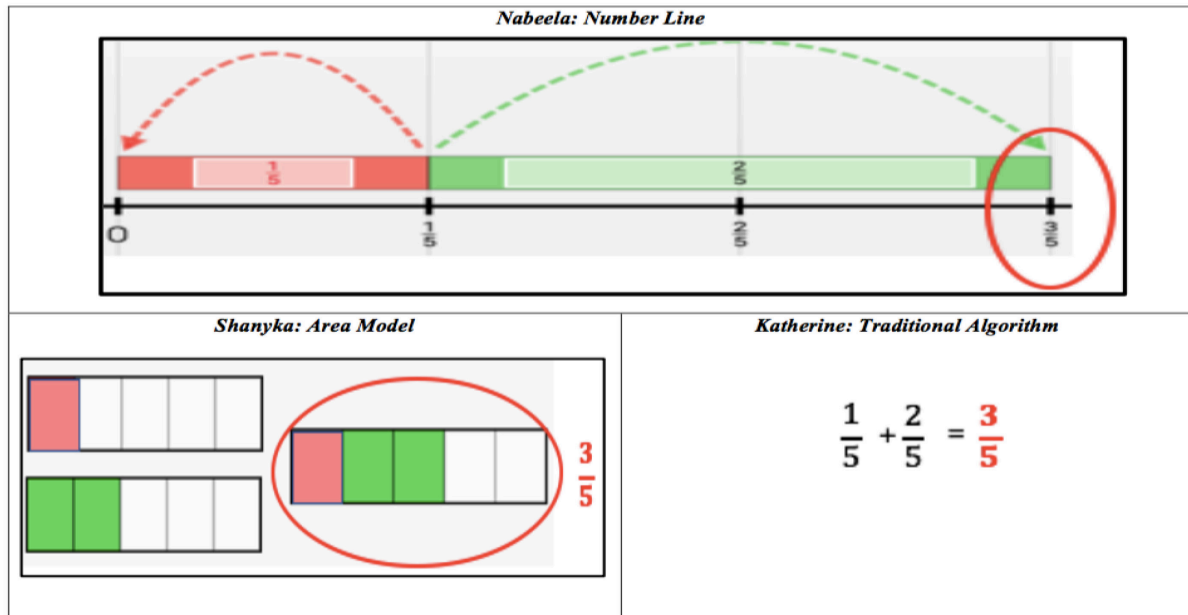


Figure 5.5: Interactive Homework Assignment Five

This session began with an assessment of Laura Jeans' understanding of fractions. The researcher presented a separate page of pattern blocks (Figure 5.6) in different configurations and asked her to identify fractions, "If the yellow block is the whole, what is the red block?" or "If the red block is the whole, what is the blue block?" Laura Jean correctly identified the fractions, demonstrating a sufficient understanding of fractions.

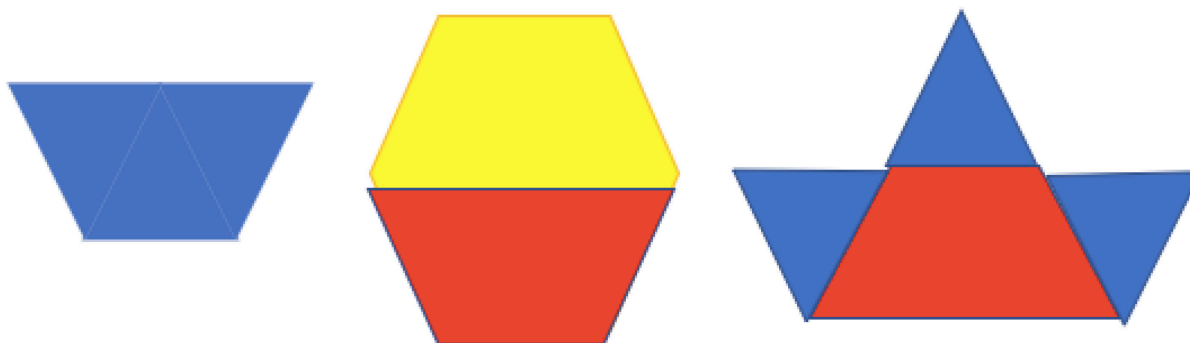


Figure 5.6: Fraction Assessment

After the assessment, the new lesson began with Linda and Laura Jean using the discussion prompts to plan which problems to select first and then their strategies for solving. Linda led the discussion:

Okay, so we got to look at each of these. These are the math problems, but we got to figure out which strategy is best for them...which model would you use for that... for plus [addition]? ... That one? That one's the best. Why?

In response, Laura Jean replied, "Cuz [*sic*] you have to draw the square in that one. If you don't know how to count that low, you could draw some," reflecting how her explanations have now expanded. Linda also discussed her plan for selection:

I think this, these ones  $[\frac{5}{17} + \frac{9}{17}]$  would be harder for the area model, trying to cut something into 17 equal bars or 20. But that would make it hard to kind of visualize. So I think the number line would be easier [for] bigger numbers, like this one right here.

While Linda remarked, "They [fraction problems] all look pretty easy," Laura Jean demonstrated confusion about adding fractions when she drew three area models instead of one to add  $\frac{3}{10}$  and  $\frac{5}{10}$ . She appeared to believe that  $\frac{3}{10}$  looked like three whole area models as opposed to three parts of one area model. Linda, who originally relied heavily on using the traditional algorithm in weeks one through three, created her own area model on their chalkboard and guided Laura Jean

on how this particular problem would only require one area model or whole. She also encouraged Laura Jean to use the conceptual models, while ignoring the traditional algorithm, which was an option for them to use.

While Linda and Laura Jean continued to solve using their models, Laura Jean's sibling, Helen, arrived, disrupting their session. As a result, Laura Jean lost focus and Linda spent the rest of the session managing Laura Jean's and Helen's behaviors. Future attempts were made to reduce the amount of disruptions by scheduling these sessions during times Linda could receive coverage.

### **Week Six**

The interactive homework six (Figure 5.7) was developed to address the participants' perspective of assignment five being too "easy" with its sole inclusion of fractions less than one. Laura Jean also demonstrated misunderstandings when adding fractions with pictorial representations by generating multiple area models for fractions less than one as opposed to working from one area model. Thus, the week six assignment included pictorial representations of fractions greater than one (e.g.,  $1\frac{3}{6}$  and  $\frac{9}{6}$ ). The word problem involved students subtracting fractions using different models and disagreeing about which student solution is correct. This problem also included fraction equivalency, which is one of the first concepts fourth-grade students learn as a foundation for understanding fraction values. This assignment was also designed to introduce Linda to problems that inspire debate and inquiry (Which student is correct and why?) to further guide her use of models to rectify Laura Jean's confusion about fraction values and adding them. Lastly, area models and number lines were included to illustrate how pictorial representations can reflect word problems to improve student understanding and simplify the problem-solving process.



Laura and Ryan reviewed and solved the word problem below using different strategies:  
*Dexter had a bracelet that was  $2\frac{2}{6}$  inches long, and it is  $\frac{5}{6}$  more inches than his friend, Cassandra's. How long was Cassandra's bracelet?*  
 They disagreed on their solutions. Who is correct?

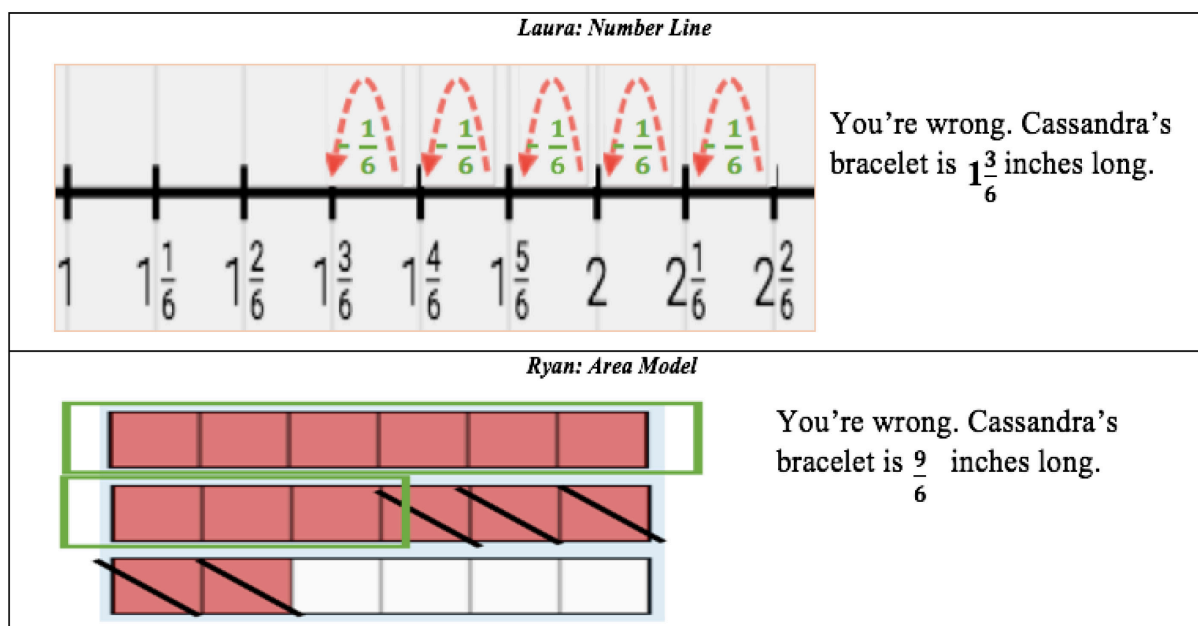


Figure 5.7: Interactive Homework Assignment Six

This session began with Linda guiding Laura Jean through the process of deciphering the word problem using the models. She read the problem first and then inquired about the area model. Then she directed her daughter's observations of the area model's parts by helping her count each section, "Do you notice anything similar? So what is it? 1...2...3...4...5...6...7...8.  $\frac{9}{6}$ ? What do you notice though. Look at, look at... the numerator, the denominator." She asked additional questions about the implications of numerators that are greater than their denominators, "What happens when the numerator is bigger than [the] denominator? Which means what? Pull out a..." to which Laura Jean replied, "A whole." Linda continued asking about the number line and counted back, "We have 1... 2... 3," and Laura Jean exclaimed, " $1\frac{3}{6}$ . They're both correct!" when she realized that  $\frac{9}{6}$  from the area model and

$1\frac{3}{6}$  from the number line were equivalent fractions. Linda provided encouragement, “Right. They just did them differently.”

When Laura Jean stated that she wanted to begin with the number line as her first strategy, Linda modeled her thinking out loud in her selection of a problem that was suitable, “Is there an easy one that we can do on a number line? I see an easy one. How about this? Three minus  $\frac{2}{3}$  because we’re only dividing while doing thirds. Right?” Laura Jean selected this strategy and began to create her number line to which Linda replied with encouragement, “Good. Perfect.” Laura Jean opted once more to do the majority of the problems similar to previous sessions (Three through Five) and accidentally created fourths on her number line, instead of thirds. Laura Jean quickly corrected herself as Linda observed, “So she [Laura Jean] actually had quarters...but when she started labeling them [the sections on the number line], she caught herself.” Laura Jean continued building her number line with both fractions greater than one and their mixed number equivalents, and Linda asked, “Well, okay, so are you trying to keep counting up? So if this is three, what's the next number for three?” to which her daughter replied, “ $\frac{4}{3}$ ,” and continued to count out loud as her mother demonstrated, “7...8...9.” Linda continued to guide her daughter, “No, you haven't done your answer yet...all you did was do your number line...all you did was represent three, and you need to take away  $\frac{2}{3}$ . You need to go back.” Laura Jean responded by counting her jumps out loud as Linda continued to question, “So which format are you writing?” to determine if she was counting back by fractions greater than one or mixed numbers. Laura Jean counted out loud, “ $\frac{7}{3}$  or  $2\frac{1}{3}$ ,” demonstrating how her number line helped her correctly count back by using equivalent fractions on her number line.

This discussion reflects their completion of the word problem section, where Linda used questioning and encouragement to guide Laura Jean's thinking and how Laura Jean responded by modeling her thinking out loud. While there were interruptions by the younger sibling, they did not interfere with their problem-solving process. Laura Jean opted to complete the majority of the problems like in previous sessions.

### **Program Fidelity**

#### **Process Question One**

Process question one is "To what degree did participants complete and use the interactive homework as intended for six weeks throughout the intervention?" As stated in chapter four, the interactive homework assignment was the primary tool of the intervention, and thus, the degree to which the assignments were completed and submitted were important indicators of program fidelity and participant responsiveness. Almost every interactive homework assignment was completed and submitted in a timely fashion by email. As stated previously, the exception occurred when Linda could not complete her second problem on assignment one because Laura Jean selected all the problems that corresponded to the adjustment strategy. Furthermore, observations and follow-up observations of the parent-child dyad were conducted to determine whether modifications were required to ensure the assignments' correct use. For example, the week three follow-up observation revealed how participants used the assignments as intended when Linda slowed Laura Jean down by reading the assignment's quick flash questions to encourage her to examine the strategies longer, "Do you wonder anything about any of these?" Additionally, the interactive homework assignments were adjusted each week to improve program implementation. Assignment submissions, assignment completion, except for the week one assignment, and observations of the participants using the interactive homework assignments correctly (e.g., using the question prompts, studying the sample problems, selecting problems

and strategies from the options available, justifying their selection of problems and strategies) indicated high participant responsiveness and program fidelity.

### **Process Question Two**

Process question two is “How did differences in participant characteristics and pandemic restrictions influence their contributions to the completion of the interactive homework assignments?” Participant characteristics and pandemic restrictions are contextual factors that influenced program implementation. Linda and Laura Jean’s relationship played an important role in their completion of the assignments. Each participant had individual mathematics experiences that influenced how they approached problem solving. Linda, college-educated with a minor in mathematics, was initially resistant to using conceptual strategies, likely due to her and her parents’ success in mathematics (One parent is an accountant, the other is an engineer.). Linda and her parents demonstrated that mathematics success in their professions and backgrounds did not require the use of conceptual strategies. Laura Jean appeared resistant to learning conceptual strategies because she had not mastered them. Furthermore, her resistance to using conceptual strategies may have been influenced by Linda, who regularly voiced in sessions one through three how conceptual strategies were inefficient.

Pandemic restrictions influenced program implementation because measures (e.g., remote instruction and home confinement) may have increased the interruptions Linda and Laura Jean experienced working on the assignments. The majority of the intervention occurred during remote instruction, an instructional model that restricts interaction to a screen. Therefore, Helen, the younger sibling, was more likely to interrupt their sessions. At times, her presence shifted the parent-child dynamic, where Linda stopped collaborating to redirect Laura Jean’s attention and manage Helen. Linda and Laura Jean’s mathematics backgrounds and the sibling’s search for

interaction resulting from pandemic restrictions were contextual factors that influenced how the program was implemented. Fortunately, the number of sessions, adjustments to the interactive homework assignments, and assistance provided during these sessions likely made the program more effective and, thus, more impervious to these distractions.

## **Discussion**

This section contains a review of the study's findings and its connection to existing theoretical frameworks, Bandura's (1986) triadic reciprocal determinism theory and Ball, Thames, and Phelps' (2008) mathematics knowledge for teaching (MKT). In addition, evaluation questions below were used to guide the examination of these outcomes. Inductive and deductive coding and validity procedures were conducted when examining entries from the researcher's journal, participant work and responses on the interactive homework assignments, and the observations to identify and confirm themes regarding the intervention's influence on parent mathematics self-efficacy and parent mathematics knowledge for teaching.

### **Coding and Validity Procedures**

Deductive and inductive coding were used when reading through the survey, observation transcripts, the interactive homework assignments, the researcher's journal, and the interview transcript. These procedures were employed to identify intersecting themes in participant perspectives and experiences using the interactive homework assignments. The researcher's journal was used to reflect on observations of participants using the interactive homework assignments and parent feedback on the interactive homework assignments. Research and outcome questions informed the development of codes before the intervention for the constructs parent mathematics self-efficacy and parent mathematics knowledge for teaching. A priori codes for parent mathematics self-efficacy were *confidence* and *comfort* using conceptual strategies, while *familiarity* and *understanding* were anticipated codes for parent mathematics knowledge

for teaching. The initial themes anticipated and generated from these data sources were later refined based on subsequent observations, parent feedback, the interview, and advisor input.

Multiple techniques were used to enhance the findings' trustworthiness. For improving the credibility of findings, data was triangulated based on multiple sources to identify intersections among different sources and identify themes (Creswell & Miller, 2000). Peer debriefing occurred as the researcher's advisor reviewed data sources either confirmed or identified additional themes. Thick, rich descriptions of the participants using the assignments were included to improve transferability, defined as how findings can be applied to other situations (Lincoln & Guba, 1985). Confirmability was established using reflexivity (Lincoln & Guba, 1985), which was employed weekly when the researcher reflected on her experiences, observations, and examinations of the participants using the assignments.

### **Outcome Question One**

Bandura's (1986) social cognitive theory was used to address outcome question one, "In what ways does the homework intervention change perceived parent participant mathematics self-efficacy?" Specifically, Bandura's (1986) triadic reciprocal determinism theory with his self-efficacy theory demonstrate how environmental factors, personal factors, and behavioral factors interact to influence an individual's life. In this research study, interactive homework assignments (environmental factors), collaboration (behavioral factor), and mathematics knowledge for teaching (personal factor) appeared to mutually reinforce each other to improve Linda's mathematics self-efficacy (personal factor). She appeared to demonstrate greater confidence in teaching Laura Jean conceptual mathematics strategies as indicated by the interactive homework assignments, observations, journal entries, and the interview, which yielded four themes: *judgment, autonomy, adjustment, and motivation*.

**Judgment.** Linda was initially frustrated by conceptual strategies (Sessions One through Four, Interactive Homework One, Interactive Homework Two). During the first four sessions, Linda's frustration appeared to stem from how she struggled to help Laura Jean realize success in mathematics when she minored in mathematics (Survey and Session Two) and shared extensive mathematics experiences with her parents (Session Four). Linda shared, "Yeah, we [family] get pretty confused. My dad's an engineer, my mom's an accountant. So... numbers, we know them" (Session Four). Linda also believed that conceptual strategies were more complicated than necessary as indicated by her response to number lines:

I don't like number lines. I really... I'm not asking you to make me do this again. But some of them seem, some problems are way harder to do with the number line because it's much more complicated math. And I feel like they should just leave that behind now [and] move on (Session Four).

Instruction appeared to offer additional challenges, primarily when Laura Jean's teachers required her to show her work using only conceptual strategies:

I think I feel like it's like, oh, you need to show your work...like I know how to do traditional, but they [her daughter's teachers] want me to show my work. So I'll just do a number line...Or she [Laura Jean] gets confused because... [she] tries too hard to come up with a model because everybody says show your work. And I really think if you just did the traditional...you're doing it, then that [is you] show [showing] your work (Session Four).

Upon debriefing with Linda at the end of sessions two and four, her disapproval of conceptual strategies appeared to be another source of concern, evidenced by her discussion of the adjustment strategy, "Yeah, I don't think I like adjustment. When I saw that... she [Laura Jean]

started doing that, I'm like, I just...don't want to change the number. I want to work [with] the number I have” (Session Four). Her dislike of the conceptual strategies also led to her resistance in using them, “I don't like number lines... I'm not asking you to make me do this again” (Session Four). Because she did not feel comfortable using the conceptual strategies, she expressed how she experienced satisfaction when she checked her answers using the traditional algorithm, “And that's when you can use the algorithm and check against like...Oh, look at it” (Session Four).

By session five, Linda's concerns about the conceptual strategies subsided as she embraced conceptual strategies to help Laura Jean understand fractions, concepts she struggled with more than whole numbers. Linda praised the number line strategy for adding fractions, “Hey, Laura Jean. That makes sense on the number line” (Session Five). Linda also appeared to value how the area model helped Laura Jean visualize adding fractions, “Like having this the area model of your picture. She could do that and see what it is” (Session Five). In the fifth session, Linda also appeared to enjoy the conceptual strategies, encouraging her daughter to add  $\frac{2}{4}$  and  $\frac{1}{4}$  using the number line and the area model strategies (Researcher's Journal, p. 5). The growing ease of guiding Laura Jean's learning with conceptual strategies was exemplified by Linda's praises replacing her initial criticisms of conceptual strategies (Researcher's Journal, p. 5).

As the sessions continued, Linda's mindset and subsequent behaviors changed from a dislike of conceptual strategies and dependency on the traditional algorithm to begrudging respect for (Interactive Homework Four, Researcher's Journal, p. 4) and eventual appreciation of conceptual strategies (Sessions Five and Six, Interactive Homework Five and Six). In previous sessions, Linda only wanted to use the traditional algorithm to help Laura Jean. By session five,



Linda stopped using the traditional algorithm in favor of the conceptual strategies and no longer encouraged Laura Jean to use the traditional algorithm when it was an available option (Session Five).

**Autonomy.** Linda began to demonstrate greater autonomy as the sessions continued (Researcher's Journal, p.4), and she became hopeful for what the assignments would bring, "Hopefully it'll help me make me more confident with my younger one [her youngest daughter] when she's doing this stuff [conceptual strategies]" (Session Four). In the first session, Laura Jean selected the two problems that would have been appropriate for solving with the adjustment strategy. As a result, she left Linda with the remaining problems that were too difficult to solve with this strategy. As Linda conveyed in the assignment's writing section, she could not complete her last problem. This incident reflected her limited authority in redirecting Laura Jean's selection of problems as she did in later sessions, four through six, when she became more confident using conceptual strategies.

By the fifth session, when Laura Jean struggled to generate an area model for adding  $\frac{3}{10}$  and  $\frac{5}{10}$ , Linda skillfully directed her to the interactive homework's pictorial representations and modeled creating the area model. Linda's reliance on the conceptual models to rectify Laura Jean's confusion was apparent in her (a) highlighting features of the conceptual strategies; (b) creating her own model as a demonstration; and (c) asking follow-up questions to deepen and assess Laura Jean's understanding of computing with fractions:

Okay. So, you know that one of these. We only need one for the tenths, and we cut [it] into 10 pieces. Three of the 10 pieces, right? Okay, but where [what] does this one represent? Do you still need these  $\frac{8}{10}$ ?

Linda's techniques were based firmly on pictorial representations, demonstrating greater confidence in using conceptual strategies (Researcher's Journal, p. 5).

Linda also began to rely less on the interactive homework's question prompts as indicative of earlier sessions to generate her own questions for developing Laura Jean's problem-solving skills (Session Five, Researcher's Journal, p. 5). She also encouraged Laura Jean to use the conceptual strategies when the traditional algorithm was as an option, "If you were to do that with the area model like this, I would make it. Okay, what about [using] the number line? All right?" (Session Five).

Evidence of greater autonomy, and thus, confidence occurred when the participants became a cohesive partnership with Laura Jean eagerly responding to Linda's questions when creating models and solving (Researcher's Journal, p. 5). Linda's questioning abilities and guidance improved from session two when she was dictating orders in response to Laura Jean's learned helplessness (Researcher's Journal, p. 2). As a result of these improvements, Laura Jean's responses progressed from limited responses and shrugs (Sessions Two through Four, Researcher's Journal, pp. 2-4) to extended answers with mathematical terms that illustrated her thinking (Sessions Five and Six, Researcher's Journal, pp. 5-6). Laura Jean also assumed the teacher role for the first time in the sixth session when she directed Linda through solving  $3\frac{2}{8} - \frac{7}{8}$  using the area model strategy: "Then you want to cross out seven of them [eighths]...Once you get all that. Boom, that's what you have" (Researcher's Journal, p. 6). This example demonstrates Laura Jean's initiative and greater confidence using conceptual strategies because she is solving problems on concepts she initially found challenging: fractions and subtraction with regrouping.

**Adjustment.** Each interactive homework assignment was adjusted based on observation and parent feedback on the interactive homework assignments, effectively conforming the

assignments to participant need to improve their confidence using the conceptual strategies. Linda's comments on interactive homework one indicated that Laura Jean selected all the problems for solving that were appropriate for the adjustment strategy, leaving Linda with problems that were only suitable for solving with the traditional algorithm. As a result, Linda was disincentivized from using conceptual strategies, believing that they were less useful because they were not appropriate for solving all problems. Thus, the directions on interactive homework two were modified to ensure that participants alternate turns when choosing problems to facilitate discussion and improve their opportunities for selecting strategies that correspond to the problems. The second assignment was also modified to include three strategies (e.g., removal, partial difference, and traditional algorithm) from the two strategies in assignment one (e.g., adjustment and traditional algorithm) to facilitate Linda's understanding and use of conceptual strategies. Additionally, at the end of session four, at Linda's request, assignments five and six were modified to include fractions. Her request reflects improved confidence in using conceptual strategies to support Laura Jean and assessing her understanding of subtracting whole numbers (Researcher's Journal, p.4).

**Motivation.** The interactive homework activities contributed to Laura Jean's motivation to engage in mathematics activities. According to Linda, Laura Jean began to enjoy mathematics because she could practice and master concepts for which she had previously struggled (Sessions Five through Six, Interview). The assignments were tailored to her areas of development. As a result, Laura Jean experienced success, which also improved her motivation to participate in the intervention (Researcher's Journal, p. 4). Her enjoyment of the interactive homework assignments and mathematics was evident when she opted to do most of the problems, instead of

sharing the responsibility equally with her mother (Sessions Three through Six, Researcher's Journal, pp. 3-5.).

Linda credited the interactive homework's collaborative nature to Laura Jean's newly-found interest in mathematics, which in turn, motivated Linda to find additional problems for Laura Jean to practice:

But it was helpful for me to work with Laura Jean and for her to have somebody else... we have the assignment to go along, but we had to do [it] together and she actually enjoyed it. So I think seeing her getting interested to study math, I think it helped, and gave us a reason to do more math. And we just said, hey, let's just do some extra, like homework or sheets I found online. And so it kind of gave us [a] purpose to do more math and work on some of the stuff that she's been working on (Interview).

## **Outcome Question Two**

Ball et al.'s (2008) MKT framework was used to address outcome question two, "In what ways does the homework intervention change perceived parent participant mathematics knowledge for teaching?" because this framework highlights essential mathematics knowledge required for effective instruction. Specifically, knowledge of content and teaching (KCT) was a construct that was addressed through collaborative learning, problem-solving tasks, and direct instruction on instructional strategies. Regarding outcome question two, *understanding* and *functionality* were themes that indicated improved parent mathematics knowledge for teaching. An examination of participant comments on the survey and assignments, observations, journal entries, and the interview indicated Linda's greater proficiency in identifying and using conceptual strategies to support Laura Jean's mathematics learning.

**Understanding.** Linda did not know conceptual mathematics strategies, which contributed to her challenges with helping Laura Jean (Survey). Due to these past struggles, she joined the study to learn more about them (Interview). Because Linda did not know the conceptual strategies for computing with fractions, helping her daughter with fractions was particularly difficult:

... I don't actually remember how to, like, do them, like subtract fractions and everything. ... I can visually and I know what the number is like, and I could do it. But I'm like actually showing her... the traditional algorithm kind of way. I'm like, I don't know that I know it [a conceptual strategy] (Session Four).

Linda's unfamiliarity with these mathematics concepts also influenced her ability to identify connections between conceptual strategies and the traditional algorithm, "I don't know. Do you see? ... The algorithm next to the example ... looks totally different to me. Like it doesn't. I don't see [the] relation" (Session Four). Yet, as the sessions progressed, Linda used the assignment's side-by-side examples to connect her mathematics background to what Laura Jean was learning in school, "So I guess it [the side-by-side example of the conceptual strategy] just informed me of what it is and kind of showed me compared to... how I learned in school. [It] kind of gave me a comparison so I can see what... I was doing compared to what I needed to be doing to show her [Laura Jean]" (Interview).

Learning more about the conceptual strategies led to Linda developing more positive beliefs about conceptual strategies. She initially expressed dissatisfaction with the adjustment strategy (Interactive Homework One, Interactive Homework Two, Session Two, Session Four, Researcher's Journal, pp.1,4), but on interactive homework four, she conveyed that the addition of the number line helped her learn the adjustment strategy, "Adjustment with the number line

helped [me] to see how adjustment work[s].” Linda’s understanding improved with the combination of two conceptual strategies she initially disliked and did not understand.

Linda’s greater familiarity with conceptual strategies and resulting improvements in her mathematics knowledge for teaching were illustrated when she relied on pictorial representations to help her daughter. For example, Linda used the side-by-side examples of the base-ten model and traditional algorithm for subtraction to help Laura Jean understand regrouping:

...when you look at just this number like that, then you don’t have to borrow. Right?

Right. So if you did traditional, you’d have to like this, right? Cross that off, make that a seven, this would become 10. Right? Yes (Session Four).

By session five, Linda’s improved mathematics knowledge for teaching was illustrated by her complete reliance on pictorial representations,” How does your picture represent three times? What part of your picture? Can you shade it?” These comments and resulting behaviors, reflective of sessions five and six, directly contrast with her dependency on the traditional algorithm in the beginning sessions (Interactive Homework One, Sessions Two through Three).

Linda’s understanding and mathematics knowledge for teaching were also demonstrated in her correct assessment of Laura Jean’s abilities. By the fourth session, Linda desired a change in content because her daughter felt comfortable subtracting whole numbers in a variety of ways, "Like she’s comfortable with this stuff. Now she fully understands it. But... She’s already [on] fractions [in class].” Her assessment matched that of the researcher with eight years of instructional experience. Moreover, although the intervention was initially created for developing a conceptual understanding of whole numbers, the researcher honored Linda’s request to work on more advanced concepts because of the observed improvements in participant knowledge of

computing with whole numbers. Thus, assignments five and six were adjusted to include fractions (Researcher's Journal, pp. 5-6).

Linda's improved understanding of conceptual strategies was also indicated by how she recognized these strategies in other parts of her daughters' learning. She identified interactive homework five's models in Laura Jean's DreamBox (an online mathematics learning resource) exercises. Linda also used this connection to help Laura Jean problem solve, "...these fractions are kind of like your square units that you were doing [on] that DreamBox. Remember how you're doing yourself?" (Session Five). She also recognized the interactive homework assignment's number line strategies in her younger daughter's class work (Session Four).

**Functionality.** Initially, Linda's limited exposure to and understanding of conceptual strategies influenced her beliefs about these strategies, as indicated by her concerns about their utility. For example, when Laura Jean mistakenly selected all the problems that corresponded to the adjustment strategy on the first assignment, Linda wrote, "Guess there are less steps in adjustment, but it can't be used in every problem and requires extra thinking." This observation demonstrated how she defined functionality by a strategy's versatility.

Linda also defined a strategy's utility by the amount of effort required to use it, as indicated by her comments on assignment two, which acknowledged advantages of the traditional algorithm for subtraction, "Traditional [algorithm] = straight forward and no extra thinking on it if it could work." The concept of the traditional algorithm's efficiency was reiterated in the follow-up observation for session three where she discussed how the conceptual strategies, "Force you to think about solving," thereby, reducing their functionality in the process.

The assignments were adjusted weekly to help Linda redefine functionality and change her mindset and confidence using conceptual mathematics strategies (Researcher's Journal, p. 2). As a result, Linda began to understand that conceptual strategies promote understanding instead of achieving an immediate answer, the traditional algorithm's purpose (Interactive Homework Assignments Three through Six, Sessions Four through Six). For example, Laura Jean spent at least two months learning the traditional algorithm for subtracting whole numbers and developing the habit of reversing minuends and subtrahends before participating in the intervention. After two sessions using the base-ten model for subtraction, Linda observed its effectiveness when Laura Jean stopped reversing minuends and subtrahends for problems that required regrouping by session four. This change illustrates how visual representations rectified Laura Jean's misunderstandings, translating to her correct use of the traditional algorithm (Session Four, Researcher's Journal, p. 4). Linda also remarked upon how learning conceptual strategies improved her understanding of the traditional algorithm, "Yeah, I mean, I think the base-ten block actually makes the most sense to me visually" (Session Four).

Linda's comments on the interactive homework four also demonstrated how her mathematics knowledge for teaching improved as her understanding of the functionality of the conceptual strategies increased, "[The] base-ten [method] worked well on small numbers. Removal was easier when [with] even numbers." She also demonstrated a deeper understanding of the adjustment's strategy purpose on interactive homework four's writing section question, "Can you predict which strategies would work best with these problems by inspection?" with the following response, "Adjustment works best when the number ends in zero." In session five, she stated how each strategy served a purpose, "I feel like [the] traditional [algorithm] works best for all of us, [pictorial representations work well with] smaller ones [quantities] ... helps so that you



can understand what it actually represents.” She further distinguished between each strategy’s purpose, “... [by] comparing the strategies we decided that the number line and area model are not good for large fractions [fractions with high denominators], right?”

With a greater understanding of how conceptual strategies function, Linda appreciated the interactive homework six’s illustration of fraction equivalency with pictorial representations and a simulated student debate:

I think...the top [of] your problem...that's a really good way to look at it. To show you know, breaking, breaking down, pointing at the whole number [and showing] that they're, neither one [of the students] is wrong. They have the same answer.

She also appeared to credit the sample problem in interactive homework five with prompting Laura Jean’s inclusion of equivalent fractions greater than one and mixed numbers on her number line as she solved (Session Five).

### **Outcome Question Three**

While an examination of multiple sources indicated Linda’s improved mathematics self-efficacy and mathematics knowledge for teaching, this study also aimed for the parent participant to identify intervention elements that improved her mathematics engagement. Outcome question three addresses participant approval, “What components of the interactive homework assignment program do parent participants identify as useful in helping them help their children with mathematics learning at home?” The themes, *repetition*, *convenience*, and *side-by-side examples*, were identified as favorable intervention components that may be included in future interventions seeking to improve parent at-home mathematics engagement.

**Repetition.** Linda discussed the importance of Laura Jean having additional practice on mathematics concepts. Laura Jean struggled to recall what she learned in school because in

previous grades, she took notes on white boards and rarely had homework (Session Three, Session Six). Linda appreciated the additional practice she received with the interactive homework assignments, “I always wanted more stuff from the school. I’m just trying to help [with] the math because I didn’t get it. And I took this opportunity as a chance to do that” (Session Four). Linda discussed how these additional resources and practice at home helped Laura Jean master concepts, “So it was helpful for her to have some extra math that wasn’t too hard to kind of talk about and stuff and see.” (Interview).

Repetition and Laura Jean’s subsequent successes in mathematics, led to her enjoyment of mathematics (Sessions Four through Six, Interview). This change in Laura Jean’s mindset inspired Linda to provide more opportunities for mathematics engagement:

But it was helpful for me to work with Laura Jean and for her to have somebody else kind of, I mean, we have the assignment to go along, but we had to do together and she actually enjoyed it. So I think seeing her getting interest I study math, I think it helped, and gave us a reason to do more math. And we just said, hey, let's just do some extra, like homework or sheets I found online. And so it kind of gave us purpose to do more math and work on some of the stuff that she's been working on” (Interview).

Laura Jean’s enjoyment of the interactive homework assignments and mathematics were also illustrated when she opted to do most of the assignments’ problems, instead of sharing the responsibility with Linda (Researcher’s Journal, pp. 3-6; Sessions three through Six).

**Side-By-Side examples.** Linda appreciated how the side-by-side examples of the interactive homework assignments helped her understand the conceptual strategies. Linda was unfamiliar with these strategies and discussed the importance of using these examples to support Laura Jean:

And so I think having that sample like above and explaining the different forms to do it helps at least a parent that knows some bit about math and doesn't know the math isn't, you know, going to figure it out unless they're learning along with their kid. But yeah, I think the hardest thing was always the she was expected to do these different models.

And I didn't know what they were (Session Four).

Linda discussed how she did not receive sufficient resources from Laura Jean's teachers and how she appreciated how the side-by-side examples helped her compare conceptual strategies and the traditional algorithm to learn conceptual strategies:

So I didn't have any of the side-by-side stuff to show the different ways in what they're supposed to be doing and how they were learning and stuff because none of it ever came ... home where she was explaining, I don't know what she was saying. So, so I guess [the examples] just informed me of what it is and kind of showed me compared to what how I learned in school kind of gave me a comparison so I can see what I was, what I was doing compared to what I needed to be doing to show her (Interview).

These side-by-side strategies and the resulting available problems informed Linda's understanding of efficiency. She emphasized the importance of these samples, "So I think having a sample of what the kids are supposed to be working on, I think, helps" (Session Six).

**Convenience.** Linda discussed how inconvenient resources and tools detracted from Laura Jean's learning, specifically citing the challenges of remote instruction that required students to complete assignments on the computer. She discussed Laura Jean's difficulties of writing on the touch-screen of her school district-provided Chromebook. Her screen was too small, and a stylus had not been provided:

It's like if the screen is bigger, it would be easy to work on but their computer screens are [too small and] it's like this big pain, and their little fingers are fat. And I guess if you had like little, like the pencils that write on screens... Yeah, that would make it easier. And I don't know if they even work with these things. But um, but yeah, it makes it really hard to write on there and then to erase and then you need to go back and take. Yeah, it's just a pain (Session Three).

Linda believed that the typing feature of Pear Deck, an interactive app for student learning, posed additional challenges for setting up problems for solving:

And if you just type and use the type part...trying to get it to like [to] type the problem and then line it up and hit their space and that ends up, it doesn't line up right and then I'm using the little line to cross the box (Session Three).

She continued discussing challenges with Chromebooks in the fourth session when she experienced difficulty locating interactive homework four to print out in color (Researcher's Journal, p.4). Given Linda's difficulties with technology, she was grateful for the easy access of the interactive homework assignments and the ability to write directly on them for problem solving (Session Three).

#### **Outcome Question Four**

Unlike outcome questions one through three, outcome question four, "In what ways does the homework intervention change the child participant's view of mathematics?" was developed after examining data sources. Although Linda was the participant of primary focus, the interactions between Linda and Laura Jean propelled their progress during the intervention. Specifically, as Linda's mathematics self-efficacy and mathematics knowledge for teaching improved, Laura Jean's mathematics skills also improved, resulting in Linda's improved mindset

and, thus, mathematics engagement with Laura Jean. Thus, the themes that emerged from the intervention in regards to question four were *initiative* and *ability*.

**Initiative.** Laura Jean's transformation from the beginning to the later sessions appeared to result from improvements in Linda's mathematics self-efficacy and mathematics knowledge for teaching. Homework session two was characterized by Laura Jean following Linda's directions on completing the problems (Researcher's Journal, p. 2, Session Two). As Linda repeated the strategies' procedures, Laura Jean quietly obeyed (Researcher's Journal, p. 2, Session Two). As Linda attempted to engage Laura Jean, she responded with one to three words, grunts, and shrugs (Researcher's Journal, p. 2, Session Two). Moreover, Linda did not answer homework two's discussion section question, "How did your partner help you learn about the strategies (e.g., encouragement, providing a great explanation)?" reinforcing the researcher's observations of how Laura Jean had not facilitated Linda's learning (Researcher's Journal, p. 2, Session Two). At the beginning of session three, Laura Jean maintained her passivity; however, after the base-ten strategy was explained, Laura Jean volunteered to complete the rest of the interactive homework problems (Researcher's Journal, p. 3, Session Three). By session four, as Linda began to follow the discussion prompts more closely to reinforce the examination of the side-by-side examples and facilitate productive dialogue, Laura Jean's motivation to problem solve continued as she experienced success using the base-ten model and traditional algorithm (Researcher's Journal, p. 4, Session Four). Linda's encouragement and praise fueled Laura Jean's willingness to continue working on math problems (Researcher's Journal, pp. 4-6, Sessions Four through Six).

Their interactions mutually reinforced each other. Linda's guidance and encouragement facilitated Laura Jean's mathematical understanding. As Laura Jean's understanding improved,

she experienced mathematics success, leading to more positive reinforcement and, thus, a greater desire to engage in mathematics. By session six, Laura Jean created models for solving and articulated her problem-solving process using mathematical language without Linda's prompting (Researcher's Journal, p. 6, Session Six).

**Ability.** Laura Jean's rapid mathematics success appeared to be the linchpin that ignited improvements in Linda's mathematics knowledge for teaching and mathematics self-efficacy as Linda observed the effectiveness of conceptual strategies. Before the intervention, Laura Jean struggled for at least two months using the traditional algorithm for subtraction with regrouping, but two sessions using the base-ten block strategy led to her correct use of the traditional algorithm (Researcher's Journal, p. 4, Session Four). In session four, Linda observed the effectiveness of conceptual strategies for improving Laura Jean's abilities with whole numbers. As a result, she requested additional practice with conceptual strategies to improve Laura Jean's understanding of fractions (Researcher's Journal, p. 4, Session Four). By session five, Linda guided Laura Jean's understanding of fractions through questioning and pictorial representations of the part-to-whole relationship. Linda had to correct Laura Jean's area models for subtracting fractions less than one; however, by session six, Laura Jean adroitly created number lines with equivalent fractions greater than one to regroup with subtraction while correcting her mistakes and explaining her process for solving. Laura Jean's self-corrections, articulation of her problem-solving process, and her adaptations of a conceptual strategy without prompting (i.e., placing equivalent fractions on the same number line to subtract) with more advanced concepts like fractions represent a marked departure from her mathematics engagement in the initial sessions.

### **Conclusion**

In alignment with existing literature, this study's findings revealed a need for providing parents with sufficient mathematics support to aid their child's learning (Goldman & Booker,

2009; Jackson & Remillard, 2005; Remillard, & Jackson, 2006). Although Linda had an extensive mathematics background, she initially struggled to help her daughter learn concepts and strategies for which she had limited exposure. Linda began to demonstrate improvements in mathematics self-efficacy in her ready use of conceptual strategies to support Laura Jean. As indicated by scholarly research, improvements in parent mathematics self-efficacy appear to stem from greater exposure to and practice with conceptual mathematics strategies and adjustments to the intervention to suit participant needs (Jay, Rose, & Simmons, 2017; Tobon & Hughes, 2020; Van Voorhis, 2011; Williams & Williams, 2019). Specifically, participants solved problems together using various strategies, and their understanding of these strategies improved through repeated practice and the use of question prompts and examples to evaluate and reflect on the strategies' effectiveness. As a result of practice and evaluation, their arsenal of strategies improved, leading to a deeper understanding of the nature of subtraction, addition, and the part-to-whole relationship of fractions. Moreover, participant learning and self-efficacy also progressed due to conditions that were controlled (e.g., the nature of parent-child discussion, opportunities for selecting different strategies) through weekly assignment modifications based on participant feedback and need. Problem-solving tasks, collaborative learning, direct instruction on instructional methods, self-guiding directions, and emotional supports were contributing factors of improved parent mathematics self-efficacy and parent mathematics knowledge for teaching.

The researcher predicted that a bilateral relationship between the parent-child partnership and their understanding of and confidence using the conceptual strategies would affect the intervention's outcomes; however, the degree of influence was not anticipated. The parent participant's knowledge and confidence in using strategies translated to the child participant's

full embrace of mathematics as she began to experience success. As a result, the parent participant, initially resistant to using conceptual strategies, actively sought additional opportunities to work together with her child to use conceptual strategies. Additional practice led to greater improvement in mathematics knowledge and confidence. Each participant fueled the other's progress likely resulting in the relatively quick growth in their overall conceptual knowledge and self-efficacy. The importance of the dynamic between parent and child collaborations cannot be overlooked in future mathematics interventions.

### **Limitations**

Linda was highly educated and of high SES with an extensive background in mathematics, and these traits possibly influenced her understanding of conceptual strategies. Thus, a question remains about the interactive homework assignments' effectiveness within the general population. Furthermore, the parent participant's mathematics knowledge for teaching and self-efficacy were likely influenced by the researcher's tailoring of the assignments to meet specific needs. This degree of modification may not be possible with an entire class of parent participants. This paper also focused directly on parent mathematics engagement, leaving additional questions about how intervention materials and program implementation can be translated to support other family members' (e.g., grandparents, siblings) mathematics involvement. These factors are important when designing an interactive homework program for the general population and different family members. Another potential limitation is that the intervention was limited to addition and subtraction of whole numbers and fractions with common denominators, areas that do not represent a limited portion of the fourth-grade mathematics standards.

### **Implications for the Future**



With learning primarily confined to the home during the COVID-19 pandemic, the need for parent support grew exponentially. The pandemic has likely forever changed how students learn, and future studies will have to identify methods that further facilitate out-of-school learning. Thus, interventions that incorporate measures that promote parent participation at home with problem-solving tasks, collaborative learning, direct instruction on instructional methods, self-guiding tools, and emotional supports may revolutionize mathematics instruction as parents learn conceptual mathematic strategies alongside their children. Future studies should also include an examination of other operations, number sets, and topics (e.g., area, measurement) that cover additional concepts of the mathematics standards.

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## Appendix A

### Needs Assessment Survey

Thank you for agreeing to take part in this important survey that will help me determine how to provide the right types of support to help you take an active role in your child's mathematical learning. This survey should only take about 10-20 minutes to complete. Be assured that your answers will remain confidential.

**Please indicate how much you agree or disagree with the following statements.**

**Response Choices: Strongly Agree (4); Agree (3); Disagree (2); Strongly Disagree (1)**

#### **Beliefs about Mathematics Learning**

1. Helping my child with mathematics homework is important to me.	4	3	2	1
2. Seeing mathematics in everyday life is important for my child.	4	3	2	1
3. It is important for my child to like learning mathematics.	4	3	2	1
4. The way students learn mathematics today is more effective than the way I was taught.	4	3	2	1
5. Mathematics is more about memorization than understanding.	4	3	2	1
6. Learning mathematical concepts such as place value is as important as learning procedures such as how to multiply $63 \times 48$ .	4	3	2	1

7. Are there any additional ideas you would like to express about mathematics learning?

#### **Conceptual Knowledge for Helping my Child**

8. I can help my child show the relationship between area and perimeter, using models such as cubes, graph paper, and string.	4	3	2	1
9. I can help my child draw pictures or use objects to model fractions.	4	3	2	1
10. I can help my child draw pictures or use objects to model fraction multiplication and division.	4	3	2	1
11. My child's teacher teaches mathematics similarly to how I learned.	4	3	2	1
12. I can help my child solve story problems and explain the answers.	4	3	2	1
13. How would you describe the way students learn mathematics today as compared to how you were taught?				

**Mathematics Knowledge for Helping my Child**

14. I can explain to my child how to multiply fractions. 4 3 2 1

15. I can explain to my child how to multiply and divide two-digit whole numbers, like 15 and 16. 4 3 2 1

16. I can explain to my child the relationship between decimals and fractions. 4 3 2 1

17. Describe your background in mathematics. 4 3 2 1

18. Describe your background in mathematics.

**Mathematics Self-Efficacy**

19. I can support my child in all their mathematics homework 4 3 2 1

20. Mathematics is my favorite subject to teach my child. 4 3 2 1

21. I know how to motivate my child to learn mathematics. 4 3 2 1

22. I am confident in my ability to explore mathematics with my child using multiple strategies. 4 3 2 1

23. Through what grades, do you feel you could help your child with mathematics?

**School-Home Communication and Support**

24. Does your child's teacher provide any of the following to assist you and your child's math abilities?  
Select all that apply.

- |                                                                                            |                                                                             |
|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| <input type="checkbox"/> Links to informational websites about learning mathematics        | <input type="checkbox"/> Books about Mathematics                            |
| <input type="checkbox"/> Informational newsletters or pamphlets about learning mathematics | <input type="checkbox"/> Music or songs about teaching mathematics          |
| <input type="checkbox"/> Frequent updates on your child's progress                         | <input type="checkbox"/> Children's books with a mathematics theme          |
| <input type="checkbox"/> Meaningful mathematics worksheets/homework                        | <input type="checkbox"/> Recommendations for apps, websites, or video games |
| <input type="checkbox"/> Instructions for mathematics activities to do at home             | <input type="checkbox"/> Parent Support Groups                              |
| <input type="checkbox"/> Toys or games about mathematics (e.g., dice games, card games)    | <input type="checkbox"/> Parent Mathematics Nights                          |
|                                                                                            | <input type="checkbox"/> Other (related to mathematics). Please explain.    |
|                                                                                            | <input type="checkbox"/> Nothing is provided by the teacher.                |

25. Please comment on any of these resources and note additional support you would like to receive.

<p>26. Any other comments that might help me provide support for parents.</p>
<p><b>Parent Characteristics</b></p> <p>27. What is your highest level of education?</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> High school graduate, diploma or the equivalent (for example: GED)</li> <li><input type="checkbox"/> Some college credit, no degree</li> <li><input type="checkbox"/> Trade/technical/vocational training</li> <li><input type="checkbox"/> Associate degree</li> <li><input type="checkbox"/> Bachelor's degree</li> <li><input type="checkbox"/> Master's degree</li> <li><input type="checkbox"/> Doctorate degree</li> </ul>
<p>28. What is your occupation?</p>

Appendix B  
Table of Interventions

Authors	Intervention Type			Component			Construct		Duration
	Workshop Interactive Homework Technology	Interactive Homework	Technology	Collaborative Learning	Mathematical Tasks	Explicit Instruction	Improved Parent Mathematics Knowledge	Improved Mathematics Orientation	
Balli et al. (1998)	Interactive Homework- <i>quasi-experimental</i>			Collaborative learning, Tasks			Knowledge		3 months
Berkowitz et al. (2015)	Technology- <i>experimental</i>			Collaborative learning, Tasks			Orientation- <i>Anxiety</i>		1 year
Husain et al. (2016)	Workshop			Collaborative learning, Tasks, Explicit Instruction			Knowledge Orientation- <i>Self- Efficacy</i>		12 sessions
Jay et al. (2017)	Workshop			Collaborative learning			Knowledge Orientation- <i>Self- Efficacy</i>		4 sessions
Knapp et al. (2016)	Workshop			Collaborative learning, Tasks, Explicit Instruction			Knowledge Orientation		5 sessions
Loehr et al. (2014)	Interactive Homework- <i>quasi experimental</i>			Collaborative learning, Tasks, Explicit Instruction			Knowledge		2 months
Lore et al. (2016)	Interactive Homework <i>randomized-control trial</i>			Collaborative learning, Tasks, Explicit Instruction			Knowledge		2 sessions
Mangram and Metz (2018)	Workshop			Collaborative learning, Tasks,			Knowledge Orientation		5 sessions
Mistretta (2013)	Workshop			Collaborative learning, Tasks, Explicit Instruction			Knowledge Orientation-Self- Efficacy		4 <i>sessions a month</i>
Muir (2012)	Interactive Homework			Collaborative learning, Tasks, Explicit Instruction			Knowledge Orientation- <i>attitudes</i>		Not provided
Tobon and Hughes (2020)	Workshop			Collaborative learning, Tasks			Knowledge, Orientation- <i>beliefs, self-efficacy</i>		6 sessions

Panaoura (2017)	Technology/Workshop	Collaborative learning, Tasks, Explicit Instruction	Knowledge Orientation	4 sessions
Papadopoulos (2017)	Workshop	Collaborative learning, Tasks	Knowledge Orientation- Self-Efficacy	1 session
Schaeffer et al. (2018)	Technology- <i>experimental</i>	Collaborative learning, Tasks	Orientation- <i>Anxiety</i>	2 years
Van Voorhis (2011a)	Interactive Homework- <i>quasi experimental</i>	Collaborative learning, Tasks	Orientation- <i>Attitudes</i>	2 years
Van Voorhis (2011b)	Interactive Homework- <i>quasi experimental</i>	Collaborative learning, Tasks	Orientation- <i>Attitudes</i>	2 years
Westenskow et al. (2015)	Observation	Collaborative learning, Tasks, Explicit Instruction	Knowledge Orientation- <i>Attitudes, Beliefs</i>	8 sessions
Williams and Williams (2019)	Interactive Homework	Collaborative learning, Tasks, Explicit Instruction	Knowledge Orientation- <i>Attitudes</i>	20 weeks
Zippert et al. (2019)	Technology- <i>experimental</i>	Collaborative learning Tasks, Explicit Instruction	Knowledge	1 session

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Appendix C

Arithmagons

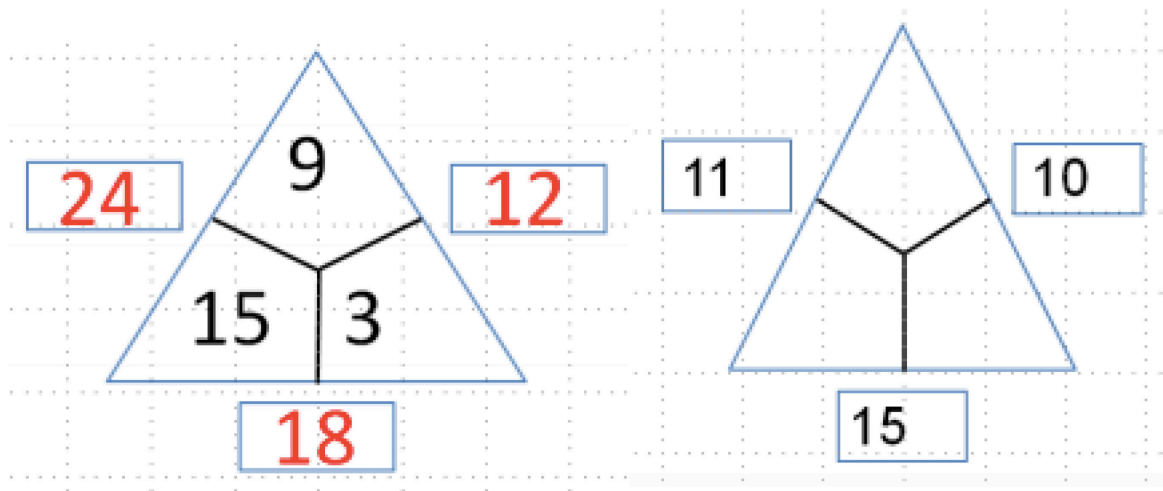
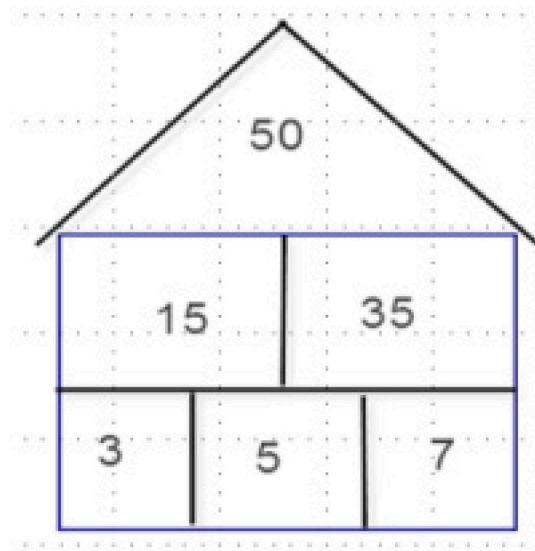


Figure 4. Arithmagons. From Papadopoulos, 2017, p. 7

## Appendix D

### Times Plus Houses

Times-plus houses are pictorial representations of houses that contain three sections (Papadopoulos, 2017). The bottom section of the house needs to be multiplied to find the middle section of the house (Papadopoulos, 2017). The middle section is added to equal the top of the house (Papadopoulos, 2017).



*Figure 5. Time Plus Houses. From Papadopoulos, 2017, p. 7*



## Appendix E

### Interactive Homework Page One

*In this assignment, we explore different approaches to subtraction to strengthen your child's understanding of numbers and develop a deeper understanding of the operation of subtraction.*

Cassandra reviewed and solved the word problem below using different strategies:

*Dexter had  $\frac{11}{12}$  of a pizza on Friday, and he ate  $\frac{9}{12}$  of this pizza on Saturday. How much pizza remained?*

Number Line	
<p>Area Model</p>	<p>Traditional Algorithm</p> $\frac{11}{12} - \frac{9}{12} = \underline{\frac{2}{12}}$
<p><b>Quick Takes</b></p> <p><i>What do you notice?</i></p> <p><i>What do you wonder?</i></p> <p><i>How are these strategies related?</i></p>	
<p><i>You have been presented with the following problems:</i></p> $\frac{13}{15} - \frac{5}{15} = , \frac{7}{8} - \frac{3}{8} = , \frac{5}{6} - \frac{2}{6} = , \frac{3}{5} - \frac{1}{5} = , \frac{11}{17} - \frac{8}{17} =$ <ol style="list-style-type: none"> <li>1.  Let's talk about it! Which strategy would you use on each of these problems and why?</li> <li>2.  Next, student, select one problem from the list! Solve using a strategy from above.</li> <li>3.  Family Member, it is your turn! Select a different problem. Solve using a strategy from above.</li> <li>4.  Next, student, select a second problem from the list! Solve using a different strategy from above.</li> <li>5.  Family Member, it is your turn! Select a different problem. Solve using a different strategy that you have not used from above</li> </ol>	

[illegible]

## Appendix F

### Interactive Homework Survey Page One

Thank you for agreeing to take part in this important survey that will help me determine how to provide the right types of support to help you take an active role during your child's homework sessions. This survey should only take about 10-20 minutes to complete. Be assured that your answers will remain confidential. By completing this survey, you are consenting to be in this research study. Your participation is voluntary and you can stop at any time. If you would like to provide additional informational, feel free to contact me at [laura\\_moore@hcpss.org](mailto:laura_moore@hcpss.org).

**Please indicate how much you agree or disagree with the following statements.**

**Response Choices: Strongly Agree (5); Agree (4); Neutral (3); Disagree (2); Strongly Disagree (1)**

1. I can help my child draw pictures or use objects to model addition of whole numbers.	5 4 3 2 1
2. I can help my child draw pictures or use objects to model subtraction of whole numbers.	5 4 3 2 1
3. I can explain to my child the relationship between addition and subtraction using pictures or objects.	5 4 3 2 1
4. I can help my child solve story problems and explain the answers.	5 4 3 2 1
5. I can help my child write story problems for equations.	5 4 3 2 1
6. Describe your experiences working with your child in mathematics.	
7. I can explain to my child how to add three-digit numbers like, 151 and 161.	5 4 3 2 1
8. I can explain to my child how to subtract three-digit numbers like, 234 and 134.	5 4 3 2 1
9. Describe your background in mathematics.	
10. I can support my child in all their mathematics homework.	5 4 3 2 1
11. Mathematics is my favorite subject to teach my child.	5 4 3 2 1
12. I know how to motivate my child to learn mathematics.	5 4 3 2 1
13. I am confident in my ability to explore mathematics with my child using multiple strategies (drawing pictures, using number lines, telling stories to model problems, etc.).	5 4 3 2 1
14. I am confident in my ability to learn new addition and subtraction strategies.	5 4 3 2 1
15. Through what grades, do you feel you could help your child with mathematics?	

Interactive Homework Survey Page Two

16. I regularly use Canvas.	5	4	3	2	1
17. I can use Canvas to share my experience with homework assignments.	5	4	3	2	1
18. I can use multiple features of Canvas (discussion boards, announcements, etc.).	5	4	3	2	1
19. Describe the resources that the school provides that helps you help develop your child's mathematics learning.					
20. What is your highest level of education? <input type="checkbox"/> High school graduate, diploma or the equivalent (for example: GED) <input type="checkbox"/> Some college credit, no degree <input type="checkbox"/> Trade/technical/vocational training <input type="checkbox"/> Associate degree <input type="checkbox"/> Bachelor's degree <input type="checkbox"/> Master's degree <input type="checkbox"/> Doctorate degree					
21. What is the occupation of the adult who provides the most mathematics assistance to your child?					

## **Laura Megan Moore**

### **EDUCATION**

#### **Doctor of Education, Mind, Brain, and Teaching**

**August 2020**

Johns Hopkins University

GPA: 3.98

Dissertation: *Interactive Homework: A Tool for Parent Mathematics Engagement*

#### **Master of Arts in Teaching, Elementary Education**

**May 2013**

Johns Hopkins University

GPA: 4.0

#### **Bachelor of Arts in Latin and Political Science**

**May 2009**

University of Richmond

GPA: 3.41

*cum laude*

### **ACHIEVEMENTS**

#### **National Board Certification for Teaching**

**December 2017**

#### **2005 National Girl Scout Gold Award Young Woman of Distinction**

**October 2005**

- Honored as one of the top 25 national Girl Scouts Gold Award recipients for an exceptional community service project. **Focus: Academic Achievement**
- The first recipient from the state of Maryland selected for this honor.

#### **Girl Scout Gold Award Recipient**

**April 2005**

Project titled: *Elementary Beginnings for High School*

### **TEACHING EXPERIENCE**

#### **Howard County Math Tutor**

**August 2015-present**

- Plan and create lessons to meet the needs of struggling students in reading and in 2<sup>nd</sup> grade math to high school geometry.

#### **Waverly Elementary**

*Teacher*

**August 2013-present**

- Plan and differentiate lessons to meet the needs of 4<sup>th</sup> grade students in language arts and above-level math.
- Tutor students before and after school in grammar, writing, and reading comprehension.
- Attend professional development training meetings in the form of the *Danielson Modules* and *Best Practices for Language Arts and Mathematics*.
- Provide a weekly announcement/video to parents in order to keep them informed of what is taught in my classroom.

- Provide materials and research-based assignments to aid colleagues in teaching math principles that are aligned with Common Core.
- Create informational videos for colleagues on how to use Canvas features and other online resources.

### **Severn Elementary**

**January 2013-May 2013**

#### *Student Teacher*

- Planned and differentiated lessons to meet the needs of 2<sup>nd</sup> grade students.
- Co-planned and co-taught with one mentor teacher for language arts and advanced math and given full-time teaching responsibilities.

### **Four Seasons Elementary**

**August 2012-December 2012**

#### *Student Teacher* Planned and differentiated lessons to meet the needs of 4<sup>th</sup> grade students.

- Co-planned and co-taught with three mentor teachers for science, social studies, reading, math, and writing and given full-time teaching responsibilities.

### **Featherbed Elementary**

**July 2012-August 2012**

#### *Student Intern*

- Supervised and monitored students during Science, Technology, Engineering, and Math camp.
- Assisted in the creation of projects.
- Performed general office duties as assigned.